LONG-TERM OUTCOME FOLLOWING SEVERE AND VERY SEVERE CLOSED HEAD INJURY DURING CHILDHOOD

Alan David Colam

A Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Clinical Psychology.

This research was carried out with the aid of a grant from the Human Sciences Research Council.

University of Cape Town

September, 1984

ACKNOWLEDGEMENTS

- to my supervisor, David Ruthenberg and colleague, Frances Hemp, whose support and criticism were invaluable;
- to the Head of the Department of Neurosurgery, Medical School, University of Cape Town, Professor J.C. de Villiers, for permission to study department patients;
- to Celeste Herbert and all other department personnel for their ready assistance;
- to Carolyn Cumpsty who gave important advice on medical points and Heleda Theron, whose work formed the basis of the study of psychosocial aspects of outcome and who interviewed a number of parents;
- to Charles Parry, who gave advice on statistical aspects of the research;
- to Judy Baumgarten and Lyndy Hill-Jowett who were responsible for the typing;
- to my parents, who have supported me in every way;
- and finally, to my classmates, Sally, Lynn, Abdul, Ann and Margie for their consistent support.

ABSTRACT

A retrospective follow-up study of nineteen Coloured subjects who sustained severe and very severe closed head injury in motor vehicle accidents while under the age of 15 years was carried out at a mean of 6,1 years post-injury. Each subject was neuropsychologically assessed using a battery of tests including those of general intellectual ability and motor, visuo-graphic, language and memory functioning. The performance of the head-injured group was compared with that of a control group of ten normal subjects matched with the head-injured subjects for race and social class. In seventeen cases a detailed follow-up interview was obtained from one of the head-injured subject's primary caretakers. The results of the study suggest that global intellectual deficit is to be found most frequently where the duration of post-traumatic amnesia exceeds three weeks. Global impairment of IQ appears to be unlikely where post-traumatic amnesia lasts for less than one week. Subjects with a history of three weeks post-traumatic amnesia appear to be pervasively impaired in tests of neuropsychological function at long-term follow-up. Results indicate that post-traumatic amnesia of over one week but less than three weeks' duration is linked with long-term impairment in manual dexterity, motor-speed and precision, visuographic functioning and language production. It is suggested that post-traumatic amnesia of less than one week is linked with impaired motor-speed and precision and deficient language production. The most frequently reported changes following closed head injury include the development of headaches and motor weakness on one or other side of the body, irritability and impatience, anxiety, a tendency to withdraw, have a low tolerance for stress and impaired ability to attend. Forgetfulness, learning difficulties and

scholastic failure also appear to be frequent sequelae. It is noted that, due to the small size of the sample, the results and conclusions are only suggestive of long-term outcome patterns in the Coloured South African who sustains severe or very severe closed head injury during childhood.

CONTENTS PAGE NO.

CHAPTER ONE

EPIDEMIOLOGY, MECHANISMS, PATHOPHYSIOLOGY AND NEUROLOGICAL ASSESSMENT OF CLOSED HEAD INJURY

1 Epidemiology

In the international literature it is generally agreed that accidents are the major cause of death in children after their first birthday, of which those due to head injury represent a large proportion, i.e. some 41% (Craft, 1972a). At all ages, boys are more often involved in head injury than girls at a ratio of from 2:1 to 3:1, although sex differences are less significant under the age of five years, (Craft, 1972a; Hendrick et al, 1964, cited in Levin, Benton and Grossman, 1982). When the child begins to walk, his mobility, coupled with a lack of appreciation of danger makes him vulnerable to falls and other injuries possible during play. Levin, Benton and Grossman (1982) note that falls are responsible for approximately one-half of childhood head injuries. Road accidents increase in frequency from the age of three years and reach a peak between six and eight years, tailing off in incidence as the child becomes more closely aware of road dangers, (Craft, 1972a). Road accidents are responsible for one-third of cases of closed head injury in childhood (Levin, Benton and Grossman, 1982) and most children injured in road accidents are pedestrians or are otherwise passengers, (Jennett, 1972). Accidents at school occur throughout the school years and tend to occur during unsupervised play and sport, (Craft, 1972a).

In Cape Town, 25,2% of non-natural deaths which have occured in children under the age of fifteen years between 1966 and 1981 have been due to head injury. Transport accidents were the major cause of fatal head injury in all races (72,4%). Assault and abuse accounted for 7,5% of fatal head injuries, followed by falls accounting for 5,5%, (Knobel, et al, in press). Over all injuries, the major cause has differed with the age of the child; in children under one year falls were most frequently the cause of injury. In the one to five year age group, transport related injuries were the most common cause of admission following head injury in Blacks and Coloureds (63,1% and 46,5% respectively), but in Whites falls were still most common (58,2%). In the six to fourteen year age group, transport related injuries were most common in all age groups. Transport accidents, falls and abuse/ assault accounted for 88,4% of all cases of head injury in the study. In the transport injuries, children were invariably pedestrians and this group was responsible for the major proportion of severe and very severe concussive injuries, multiple injuries and instances of death in the sample as a whole, (de Villiers, et al, in press).

2 Types of Head Injury

2.1 Focal Head Injury

Damage to brain matter which is restricted to a particular area is regarded as focal. Such an injury is likely to be 'open', i.e. the skull will have been penetrated as occurs in cases of gunshot, stab wounds or depressed skull fracture where pieces of bone have lacerated underlying tissue. Focal damage may also occur as a result of haemorrhage. Focal injuries are very rarely associated with loss of consciousness, (Jennett, 1972). However, where haemorrhage is present, loss of consciousness may well occur, but will not be immediate.

2.2 Diffuse Head Injury

Damage to brain matter which has been pervasive, including large areas of the brain, is regarded as diffuse. Diffuse injury is commonly 'closed', i.e. the skull is not penetrated, although skull fractures do occur at times and are often linear in nature. This type of injury is most often caused by blunt objects as in acceleration - deceleration accidents, e.g. motor-vehicle accidents and falls from heights. Diffuse injury is always associated with fairly immediate loss of consciousness, (Jennett, 1972).

When a head injury of either of the above types is sustained, damage to brain matter may be primary or secondary.

3 Primary Brain Damage

The brain matter is primarily damaged in three main ways: by cerebral concussion, by contusion and by laceration.

3.1 Cerebral Concussion

3.1.1 Definition, Mechanisms and Pathophysiology

Concussion is the term given to the reduction in awareness and responsiveness of the brain commonly known as loss of consciousness and coma. Cerebral concussion is the basic phenomenon of closed head injury, (Ommaya, 1982).

It has been defined by Bannister (in Kolb and Whishaw, 1980) as -

> '... a condition of widespread paralysis of the functions of the brain which comes on as an immediate consequence of a blow on the head, has a strong tendency to recovery, and is not necessarily associated with any gross organic damage in the brain substance.' (p 83)

While there may not necessarily be any gross organic damage when concussion occurs in its milder forms, recent literature has indicated that under severe impact structural damage occurs in the brain stem and diffusely throughout the white matter of the brain. Damage to the brain stem following closed head injury has been found in the presence of haemorrhages in the periaqueductal grey matter, subjacent to the fourth ventricle, in parts of the tegmentum of the mid-brain deep to the lateral mesencephalic sulcus and, less often, along ventrolateral borders of the mid-brain, pons and rarely the medulla, (Budzilovich, 1976). Mayer (1967, cited in Budzilovich, 1976) has found that peripherally located haemorrhages are predominantly arterial while those around the aqueduct and fourth ventricle are venous in origin. However, primary damage is not restricted to the brain stem and there have been numerous reports in the literature of diffuse damage in the white matter following severe closed head injury, (Strich, 1956, 1961, 1967, 1970). Evidence for white matter abnormality has been found in the tearing of nerve fibres (as a result of shear strains, discussed later). Strich (1961) has argued that the presence of numerous retraction balls found at the end of interrupted nerve fibres, changes in the white matter of the cerebrum and in long tracts of the brain stem and spinal cord as well as gross tears in the corpus callosum and superior cerebellar peduncles, supports the hypothesis of stretched and torn nerve fibres under the pressure of shearing strains on the brain matter at impact. Oppenheimer (1968) found that microglial stars occur in the white matter of patients who have sustained a clinically trivial head injury which is further evidence of minor but diffuse damage to white matter in concussion.

In detailed research in the area of the mechanisms underlying the damage found secondary to concussive injury, Ommaya and Gennarelli (1974) and Ommaya (1982) have suggested that head injuries may be either static or dynamic events. Static injuries are defined as consequent on forces which are applied slowly, i.e. with durations of over 200 milliseconds. Static loading is uncommon as a cause of injury and when it does occur, by means of a slow crushing event for example, injury is primarily focal in nature. Closed head injury, on the other hand, is primarily dynamic, i.e. it occurs with forces applied with durations of under 200 milliseconds at a time, (Holbourn, 1943, cited in Ommaya and Gennarelli, 1974). Most closed head injury is the result of direct impact to the head, although indirect loading of the head can also result in brain damage, e.g. falls on the buttocks and severe hyperflexion - hyperextension injuries produced by violent shaking of the head, which occurs predominantly in abused children and 'whiplash' injuries.

Direct impact results in (1) contact phenomena and (2) inertial loading. Contact phenomena include shock waves, skull bending or skull fracture which may produce primarily focal injuries. These may be trivial or significant depending on severity of impact and the location of the focal lesion. Inertial loading includes two basic mechanisms: translation and rotation. Translation is defined as movement of the brain in a linear manner, whereas rotation implies movement through any angle. Ommaya (1982) postulates that, due to the linear nature of its movement, the translation mechanism causes only focal injury. However, rotation is regarded as the key determinant of diffuse injuries. It is the effect of rotation, coupled with that of translation and the focal effects of contact phenomena which produce brain damage after closed head injury, as a result of shear, tensile and compressive strains on the soft viscoelastic brain matter.

Ommaya and Gennarelli (1974) state that the damage within the brain matter under the influence of rotation follows a general principle of theoretical physics: impacts to the mobile head cause effects that will be minimal at the centre of the brain and intensified at specific peripheral locations of tissue transitions, particularly when these transitions are caused by a bony or dural protrusion. Conversely, surface injuries to the brain will be minimised where the skull interior is smooth and there are no venous attachments, e.g. over the occipital lobes as compared with the area of the frontal and temporal lobes. In a situation of severe impact, Ommaya and Gennarelli argue that the severe shear strains resulting from it affect progressively deeper parts of the brain. When the diencephalic and mesencephalic core is affected, a cerebral concussion occurs with coma, paralysis confusion and amnesia. Where the impact is very severe, the outer brain layers become disconnected from the recovering brain stem, which then becomes the only operative area of the central nervous system and a persistent vegetative state ensues. Where the brain stem is too severely damaged to retain adequate control of vital functions, death occurs. The work of Holbourn, (1943, 1945, cited in Ommaya and Gennarelli, 1974) supports this hypothesis: he argued that when the brain matter is distorted at impact, parts of it drift relative to each other and stresses and strains tear nerve fibres, synapses and blood vessels. Holbourn found evidence of old haemorrhages where the consistency of the brain changed (e.g. under the ependyma, or at the junction of the white matter and the cortex of the basal ganglia areas) where shear strains would be expected to be greatest.

The effect of impact is not entirely anatomical: the more severe the injury, the more structural damage is likely to occur, but physiological functions are always operating. Gennarelli, (1982) has pointed out that physiological dysfunction can occur in the absence of structural or anatomical disruption and the degree of physiological functional disruption is always greater than the degree of anatomical disruption. The disruption in physiological function causes temporary diffuse cerebral hemisphere disconnection from the brain stem reticular activating system. Where no anatomical disruption occurs (i.e. actual tearing of fibres in both hemispheres) the electrochemical milieu of the brain returns to normal and the usual relationship between the cerebral hemispheres and the brain stem is restored, true consciousness returns and the brain recovers full function. However, where anatomical or structural damage occurs to the brain matter, residual sequelae are likely to be found once physiological functions recover and consciousness returns.

Ommaya (1982) has pointed out that, in concussion, there is always an association between loss of sensorimotor control and coordination (i.e. paralytic phenomena) and memory disturbance (i.e. amnesic phenomena). Lesser grades of cerebral concussion are not associated with sensorimotor paralysis,(i.e. amnesic phenomena are dissociated from paralytic phenomena) but the more severe concussive injury results in both. Amnesic phenomena following concussion are of two types: retrograde amnesia and anterograde or post-traumatic amnesia.

3.1.2 Retrograde amnesia

This is defined as a loss of memory for the period of time before and during the accident. In most cases of cerebral concussion it generally lasts for a period of less than one day. A retrograde amnesia extending for a time period of days to months is normally transient: most patients who have been unconscious for longer than one hour will initially have a period of retrograde amnesia which is fairly long. With recovery, the time period decreases to loss of memory for only a short span of time (i.e. duration of a few minutes). When retrograde amnesia does not shrink and memory loss for the events in a time period of months remains, significant structural damage to brain matter is indicated, such damage having been found to occur most frequently in the medial aspects of the temporal lobes. (Schachter and Crovik, 1977).

3.1.3 Anterograde/Post-traumatic Amnesia (PTA)

Post-traumatic amnesia is defined as a loss of continuous memory, i.e. the patient is conscious but confused, disoriented, suffers from retrograde amnesia and, at a given point, is unable to remember the events of previous time periods. Thus the patient is unable to store and retrieve new information. Memory may be sporadic during the period of PTA, i.e. periods of transient recovery known as 'islands' of memory occur and are followed by a further period of PTA, (Schachter and Crovik, 1977). PTA duration increases with increasing duration of coma and is considered by a number of researchers in the literature to be one of the most efficient measures of the severity of head injury (Artiola i Fortuny, et al, 1980). However, the concept is seldom used outside the Oxford School in Britain or in Continental Europe or North America. Part of the reluctance in using it has been caused by the difficulty encountered in assessing its duration accurately. Some studies have relied on the patient's report as to when continuous memory returned and others have assessed continuous memory from day to day in the ward situation. However, Jennett (1976) points out that given this difficulty, it is generally possible to assess duration within the broad time spans which are linked with degrees of severity (see Table 1). When loss of consciousness lasts for twenty-four to thirty-six hours post-injury, PTA lasts for several days; coma lasting for a minimum of six hours has been positively correlated with PTA of over seven days duration, (Jennett, 1976).

TABLE 1. DURATION OF PTA AND SEVERITY OF INJURY
(Jennett, 1976)

DURATION OF PTA	SEVERITY
< 5 minutes	Very mild
< 1 hour	Mild
1 to 24 hours	Moderate
1 to 7 days	Severe
> 7 days	Very severe
> 4 weeks	Extremely severe

3.2 Contusion

Kolb and Whishaw (1980) define contusion as primarily a vascular injury which results in bruising, oedema and haemorrhage. In blunt head injury, contusions of the cerebral cortex characteristically lie beneath the site of impact (coup) or on the under-surfaces of the frontal lobes and the tips of the temporal lobes as a result of contrecoup impact, (Teasdale, 1976). The damage at the site of contrecoup damage is frequently more severe than that at the site of impact (coup). In serious diffuse injury with rotation and a high degree of force at impact there may be multiple sites of contusional injury to the brain matter. Contusion is much less common in children under three years due to a lower frequency of contrecoup injury at that age, (Courville, in Craft, 1972a). After three years the incidence approximates that found in adults.

3.3 Laceration

Kolb and Whishaw (1980) define laceration as contusion which is sufficiently severe to physically breach the brain substance. Laceration is most frequently caused by penetrating injury caused by missiles or fragments of bone damaging the brain substance beneath a compound depressed skull fracture and is therefore characteristically associated with focal injury.

4 Secondary Brain Damage

Secondary damage to the brain is most frequently caused by haematoma which is defined as local swelling filled with effused blood (Klob and Whishaw, 1980) and cerebral oedema (swelling).

4.1 Extradural Haematoma

Extradural haematoma occurs as a result of bleeding from arteries and veins between the calvarium and cerebral surfaces which compresses the underlying brain. In the adult extradural bleeding occurs most frequently with fractures of the skull. However, it frequently occurs in children without skull fracture due to the reactive plasticity of the skull and the looseness with which the dura matter is attached to the overlying calvarium. Classically, extradural haematoma is temporal in site, resulting from tearing of the middle meningeal artery. (De Vivo and Dodge, 1971).

4.2 Subdural Haematoma

The acute subdural haematoma evolves within hours or days after injury. At times, there is a lucid period after concussion resolves followed by a deteriorating level of consciousness due to haemorrhage. However, this is seldom found clinically and more often in serious head injury the effects of a developing mass lesion appear before recovery from the immediate effects of trauma has taken place. At all ages, subdural haemorrhage and effusion is the most common single problem, (Craft, 1972a).

4.3 Intracerebral Haemorrhage

Intracerebral haemorrhage occurs where bleeding takes place within the brain substance itself and is most frequently due to disruption of small pathological dilations on the internal arteries. The bleeding damages the brain tissue in the area. Sequelae correspond to the extent of the tissue damage. Intracerebral haematoma is the least common type of haemorrhage in children, (Jamieson and Yelland, 1968, 1972a and b in Craft, 1972b).

4.4 Cerebral Oedema

Oedema (swelling) is generally found in the white matter adjacent to contusions and haematomas, (Teasdale, 1976). Diffuse cerebral oedema, which refers to swelling of both hemispheres, tends to occur frequently among children, (Bruce, 1982).

All of these secondary processes compress the brain matter, raising intracranial pressure and causing tentorial herniation and brain drift, which lead to brain stem compression. Each of these forms of haemorrhage may occur with another form, i.e. any combination of the three may occur and the risk of mortality rises with multiple sites of haemorrhage, (Craft, 1972). Ischaemic damage may occur in a pattern of global reduction of cerebral blood flow (found in up to 60% of fatal head injuries by Jennett et al, 1973 and Adams, 1975, cited in Teasdale, 1976). Children are susceptible to vomiting and associated aspiration and asphyxiation as well as early post-traumatic seizures, all of which may lead to decreased oxygenation and damage to the brain matter, (Jennett, 1972).

5 Assessment of Head Injury

5.1 Neurological Assessment

A complete neurological examination can be performed only in an alert and cooperative patient. Since patients admitted following severe diffuse head injury are, by definition, unconscious, the complete examination is not possible. Thus a specialised approach is used. The patient's level of consciousness is the most important clinical sign in the assessment of head injury, (Tabaddor, 1982). Teasdale and Jennett (1974) have developed a method for assessing the severity of injury by depth of coma: the Glascow Coma Scale, which is widely used in the literature and in Cape Town.

5.1.1 Glascow Coma Scale

The Scale allows for observation of three areas: the type of stimulus required to cause opening of the eyes, the type of motor response to command and/or painful stimulus and verbal response. The best verbal and motor responses are recorded, the motor response score taken from the side of the body which performs most highly, according to a set of well-defined responses which indicate an increasing level of dysfunction. A score is given to the response found in each category and the resultant three figures totalled to give a final score out of fifteen which indicates the level of coma presented. A higher or lower score corresponds directly to a higher or lower level of central nervous system functioning. A summary of the scale may be found in Table 2. The following more detailed description of the scoring and implications of the scale is taken primarily from Teasdale (1976), the three sections of the scale being discussed in turn.

TABLE 2. GLASCOW COMA SCALE
(Jennett and Teasdale, 1977)

Eye Opening	4 Spontaneous
	3 To speech
	2 To pain
	1 Nil
Best Motor Response	6 Obeys
	5 Localises
	4 Withdraws
	3 Abnormal flexion
	2 Extends
	1 Nil
Best Verbal Response	5 Orientated
	4 Confused conversation
	3 Inappropriate words
	2 Incomprehensible sounds
	1 Nil

Lowest Score is 3; Highest Score is 15

5.1.1.1 Eye Opening

Spontaneous eye opening indicates that arousal mechanisms are active, although it does not necessarily imply that the patient is aware of events occurring around him. If eyes do not open spontaneously, verbal command is attempted, followed if necessary by painful stimulation, applied by pressure on the patient's fingertips. Once the patient has been roused as fully as possible, speech and motor performance are assessed.

5.1.1.2 Verbal Response

Orientation is assessed by asking the patient who he is, where he is and the date, which facts must be known for full scoring. Conversational exchange short of this is termed confused. Inappropriate words refer to intelligible articulation used in an exclamatory, random way. Moaning and groaning are defined as incomprehensible sounds. Care must be taken with the verbal scale applied to children: it cannot be used with a pre-verbal child and one who is dysphasic, (i.e. the deficit is not necessarily due to impaired consciousness).

5.1.1.3 Motor Response

Obeying commands is judged from the response to instructions, e.g. lift the arm, protrude the tongue. Localisation (raising the arm above the eye) is assessed by application of pressure over the supraorbital notch, after fingertip pressure has been applied to induce a response.

Flexion responses may vary between normal rapid withdrawal and abnormal slow dystomic movements in which the limbs assume stereotyped postures.

Extension responses are highly abnormal. Differences in motor response between the two sides is indicative of focal damage in the context of diffuse injury, if loss of consciousness has been fairly immediate.

5.1.2 Further Neurological Indices

Teasdale (1976) points out that where the patient is unconscious after injury it is more important to lateralise rather than localise a lesion, i.e. it is more important to assess in which hemisphere the major damage has occurred or in which a mass lesion (haematoma) is developing. Dysfunction is almost always contralateral to the side of the brain which is most dysfunctional.

Hemianopia is assessed by the absence of blinking when a patient is threatened from one side.

Unilateral facial weakness is indicated by a cheek blowing out during respiration or by lack of contraction in response to a painful stimulus.

Hemiparesis (or weakness of limbs) may be observed by lack of spontaneous movement on one side of the body. When both arms are held upright and then released, hypotonia and paresis are indicated by the more rapid collapse of the affected limb. Asymmetrical response to a painful stimulus is an important indication of lateralised dysfunction, as is the presence of abnormal flexion or extension posturing on one side.

Hemiplegia (paralysis of the limb) may also occur contralaterally to the lesion.

<u>Dysphasia</u> (speech defect, e.g. inability to find words, but not total linguistic defect as in <u>aphasia</u>) may also indicate dysfunction of the dominant lobe.

5.1.3 <u>Ocular examination</u>

Examination of the size and reactivity of the pupils and movement of the eye is indicative of brain stem functioning. In deepening coma, the pupils are fixed and dilated, unresponsive or poorly responsive pupils indicating severe brain injury. Fixed and dilated pupils unilaterally are indicative of a supratentorial expanding mass lesion with midline shift of the brain matter, uncalherniation and compression of the third cranial nerve.

Spontaneous eye movements in lighter coma are usually roving and may be conjugate or dysconjugate (the eyes move together or do not respectively). Horizontal roving eye movements indicate that the mid-brain and pontine tegmentum are intact. In deep coma there are no spontaneous eye movements and the integrity of brain stem function may be tested with the oculocephalic response or the oculovestibular reflex. In the latter, cold water is injected into the external ear. If brain stem function is not severely depressed, this provokes eye movement after a twenty to thirty second delay. Nystagmus will occur if the reticular activating system is functioning. Dysconjugate ocular deviation indicates either a lesion of the third nerve or of the medial longitudinal bundle within the brain stem. Absence of eye movement signals a severe degree of brain stem dysfunction, (Teasdale, 1976; Tabaddor, 1982).

5.1.4 Motor examination

Decortication or decorticate rigidity refers to the abnormal flexion of the arm and hand and extension, interial rotation and plantar flexion of the lower extremity.

Decerebration or decerebrate rigidity is defined as abnormal extension and pronation of the arm with extension of the lower extremities accompanied by plantar flexion. Both are frequently seen in patients with severe head injury, (Tabaddor, 1982).

5.2 Medical Technological Assessment

5.2.1 Computerized Axial Tomography (CAT Scan)

This relatively new procedure has largely replaced older techniques in neurology such as arteriography and an encephalography (pneumoencephalography). the CAT scan uses a computer to depict the condition of a thin, horizontal slice or plane through the head, several 'cuts' being made at different levels. This procedure is able to accurately locate focal lesions of all kinds including the presence of haematoma and the extent of damage to cerebral tissue in closed head injury, (Walsh, 1978).

5.2.2 Electroencephalography (EEG)

This technique records the electrical activity of the brain through the skull by means of electrodes placed on the scalp. The potential differences between two points on the skull produced by brain activity are amplified and recorded. The EEG is useful in the investigation of epilepsy and the localisation of lesions. However, a normal recording never rules out the possibility of dysfunction as the EEG is not completely sensitive, (Walsh, 1978).

6 General Principles of Management

The major principle of management of closed head injury is the prevention of secondary brain damage (haematoma, diffuse swelling) after the primary damage sustained at the time of the accident. This is prevented by early diagnosis of developing mass lesions using the above procedures and rapid neurosurgical evacuation of haematoma, or elevation of a depressed skull fracture, or medical treatment of oedema and raised intracranial pressure.
Extracranial injuries (often a result of the accident, i.e. injury to other parts of the body) are treated and complications, e.g. hypotension and hypoxia which compromise cerebral function, are prevented. The primary treatment for cerebral concussion is bed-rest, the level of consciousness being continually monitored for signs of deterioration which may indicate that a mass lesion is developing, (Teasdale, 1976; Kolb and Whishaw, 1980).

7 Summary

Closed head injury is most frequently the result of acceleration-deceleration injuries incurred in motor vehicle accidents and falls from heights. Primary damage to brain matter in closed head injury is diffuse as a consequence of cerebral concussion, contusion and laceration caused by the rotational and translational movements of the matter in the acceleration-deceleration mechanism coupled with specific damage to the matter at the point of impact. Secondary damage to brain matter following closed head injury occurs as a result of haematoma and cerebral oedema, the latter being a frequent occurrence among children who suffer head injury of this type. The effect of impact is both physiological and anatomical: the more severe the injury, the more likely it is that structural damage will have occurred and consequently that residual symptoms will become apparent when the physiological dysfunction clears. Apart from loss of sensorimotor control and coordination, the effects of cerebral concussion include memory disturbances in the form of retrograde and post-traumatic amnesia which are revealed when consciousness is recovered. Post-traumatic amnesia is held to be the most efficient indicator of the severity of head injury by a number of authors, an injury being regarded as severe where the duration of post-traumatic amnesia exceeds one day. However, on admission, the level of consciousness is considered to be the most important clinical sign and the Glascow Coma Scale has been widely used in the assessment of depth of coma. Further important assessment techniques include the neurological examination and medical technological assessment in the form of computerised axial tomography (CAT Scan) and electroencephalography (EEG).

CHAPTER TWO

OUTCOME OF CLOSED HEAD INJURY IN CHILDHOOD

1 Importance of data informing prognosis

Jennett, *et al*, (1975) defines prognosis as a probability statement which assumes a logical relationship between outcome and certain items of antecedent data. The establishment of a body of knowledge about prognosis for the severely head-injured child is important for the purposes of (a) preventing or anticipating complications, (b) assessing methods of management, (c) allocating appropriate follow-up resources (i.e. intensive care, rehabilitation), and (d) advising the patient and his family with regard to expected long-term outcome.

This chapter will focus on the prognostic data available in the literature in the event of a child suffering a severe closed head injury. While the data has primarily to do with children, detail with regard to prognoses in adults will also be presented where appropriate. Four major areas of outcome will be presented: physical and neurological sequelae, overall intellectual and specific neuropsychological sequelae, psychiatric sequelae and finally psychosocial sequelae. Factors influencing the level of recovery, e.g. age, the duration of coma and post-traumatic amnesia and the presence of medical complications, will also be discussed.

As Levin, Benton and Grossman (1982) have pointed out in their review of the field, some research reports have tended to convey a misleading impression of quality of outcome following closed head injury by discussing outcome in terms of "good recovery" or "moderate disability", (Bruce, Schut, Bruno, Wood and Sutton, 1978; Jennett and Teasdale, 1981) where these terms refer to improved motor function (i.e. the child is able to walk) and adjustment to activities of daily life (i.e. the child is capable of a level of self care which is reasonably appropriate for his age). It is quite possible that a child able to walk and care for himself may suffer from a wide range of subtle neuropsychological deficits. Levin, et al, (1982) cited the work of Brink, Imbus and Woo-Sam (1980) as an example of a group of severely injured children, most of whom were able to walk and care for themselves, but of whom more than 90% were found to manifest abnormal neurological signs and 66% were cognitively impaired at follow-up one year after injury. It is useful to bear this point in mind where research using these broad categories of outcome is discussed in this chapter.

2 Mortality rate

Figures from different sources vary: in children with particularly severe head injuries reported by Hendrick, (1959, cited in Bruce, et al, 1978) the mortality rate was 44% and Pazzaglia, et al, (cited in Bruce, et al, 1978) reported a 35% mortality rate for children under 10 years, and 42% mortality in those between the ages of 11 and 20 years. Becker, et al, (1977) found a 22% rate in patients aged 0 to 20 years. Carlsson, et al, (1968) records a 24% mortality rate in cases aged 0 to 20 years, but notes a rate of 10 - 15% in patients younger than 10 years. This much lower figure is supported by Bruce, Schut, Bruno, et al, (1978) who record a mortality rate of 6% in a group of fifty-three patients of mean age 7,2 years who had sustained severe head injury. Comninos (1979) records a mortality rate of 10% in infants (1 - 18 months old) and 20% in children (18 months to 14 years old), following severe head injury. Bruce, (1982) records a 13% rate in cases presenting with decerebrate posturing (equivalent to a Glascow Coma Scale score of 4) and a 50% mortality rate for those who are in coma and flaccid.

Carlsson, et al, (1968) found a steady mortality rate of 30% due to primary injury (death within 48 hours) with a steadily increasing death rate (up to approximately 50%) in secondary injury (death within three days to one week) corresponding to increasing age i.e. 31 - 71 years. These figures are supported by Jennett, Teasdale, Galbraith, et al, (1977). Bruce, et al, (1978) argue that the low rate (6%) found in their study of children was due to better control of secondary complications (brain swelling, intracranial hypertension, cerebral ischaemia complicated by infection, or pulmonary difficulties). It may thus be suggested that studies placing the mortality rate at higher values among children have not adequately distinguished between primary and secondary death. However, in general it would appear that mortality in children following severe closed head injury occurs at a rate of 10 - 30% which is lower than that in adults (30 - 50%). Given the figure of 50% mortality in children displaying flaccid coma on admission by Bruce (1982), it is possible that mortality rates differ in children depending on their specific condition at admission.

3 Physical and neurological sequelae

Almost all studies of outcome following severe closed head injury which have looked at this group of sequelae have documented their presence. Physical features are dependent on the area of the brain damaged. Isolated cranial nerve signs occur, but physical features generally fall into two groups: those due to hemisphere damage (dysphasia, hemianopia and hemiparesis) and those due to brain-stem damage (bilateral spasticity, dysarthria and cerebellar ataxia), (Jennett, 1972).

Hjern and Nylander (1962) found neurological sequelae in 13 out of 22 patients (59%) from six months to nine years after severe injury (defined as loss of consciousness for longer than 24 hours). Three children were found to be severe invalids and were neurologically cerebrally palsied. The other ten were not invalids but had slight to serious symptoms from a range of difficulties including partially diminished hearing to complete deafness, psychomotor epilepsy, loss of facial sensibility and facial paralysis and slight to moderate spastic paralysis of the extremities. In a study by Brink, et al, (1970) of 52 very severely injured children with a mean duration of coma of seven weeks, assessed one to seven years post-injury, spasticity was found in 93% of the sample, the incidence of moderate to severe impairment increasing three times in the group of children who were unconscious for four weeks or more. The particular incidence of bilaterial spasticity was noted to increase in this group. Ataxia was found to some degree in 28 of 46 patients (61%) of whom 19 (41%) were minimally ataxic, i.e. the ataxia was not sufficiently severe to interfere with most motor activities, although intention tremor was present when finger-to-nose, heel-to-shin or rapid successive movements were performed. Nine patients (20%) were moderately to severely ataxic i.e. intention tremor was severe to the extent that simple tasks such as self-feeding could not be performed or walking was limited due to impaired balance. Three patients were unable to walk at all. Less frequently, sensory deficits, visual disturbances, hearing loss and seizures were noted. Sixteen patients had normal speech (35%), twenty had an articulation deficit (43%) and six had varying degrees of expressive aphasia (13%). Speech recovery paralleled that of motor function; and all patients in the study showed at least partial recovery of motor skills. Black, et al, (1971) found an initial rate of neurological deficit at discharge from hospital of 24% in a sample of 105 children, the residual rate being 15% at follow-up. Black found that most of these residual abnormalities were minor, i.e. they did not constitute a serious handicap in the majority of patients, e.g. unilateral hyper-reflexia. However, their study included children with any duration of coma as well as children who had not lost consciousness at all. In their study of 36 children between four and ten years post-injury, who were unconscious for longer than 24 hours following trauma, Heiskanen and Kaste (1974) found hemiparesis in twelve patients (33%). Five had cranial nerve signs: unilateral and bilateral optic nerve injury, third nerve palsy and homonymous hemianopia. In the prospective five year follow-up carried out by Klonoff, Low and Clark (1977) neurological deficits were found to be least likely to recover: 38% of children under nine years and 31% over nine years at the time of injury were found to have residual neurological sequelae at the five-year follow-up. Recently, in a study of 344 subjects with a median duration of loss of consciousness of five to six weeks, Brink, et al, (1980) found that, at one year post injury, 73% were independent in ambulation and self-care, 10% had regained some degree of motor function but had significant limitations in ambulation and other motor skills and 17% were totally dependent for all care, either in a vegetative state or with severe spasticity and/or ataxia. A combination of spasticity and ataxia was the most frequent outcome (39%), while spasticity alone was found in 38% of the sample and ataxia alone was present in 8%. Only 10% of the sample were found to be normal on neurological examination at follow-up. It would appear that the rate of neurological sequelae falls between 30 and 40% where consciousness is lost for 24 hours and longer post-injury, the incidence rising steeply where injury is very severe (coma duration of approximately 7 weeks).

3.1 Post-traumatic epilepsy

Figures vary in the literature, but the general trends are as follows: the risk of an early seizure (within one week of injury) following severe closed head injury falls between 5 and approximately 10%. This risk is increased to 15% in the presence of a depressed fracture (risk is also increased in the presence of a penetrating wound) and the figure rises to 30% where an intracerebral haematoma is found. Risk of a late seizure (between one week and six years post-injury) is between 4% and 7% in the absence of an early seizure. However, in a case in which a child has suffered early seizures the risk of late seizures rises to the region of 20%. Black, et al, (1971) found a direct relationship between duration of coma and the development of seizures: 7% of children without loss of consciousness, 15% with loss of consciousness under one hour and 55% with loss of consciousness for longer than one hour developed seizures. Klonoff, et al, (1977) found evidence of EEG abnormality in 15% of severely injured children under nine years old and in 5% of children over nine years old at five-year follow-up. Klonoff, et al, suggest that the EEG record was stable in terms of return to normal and was often associated with other positive clinical findings, which findings supported conclusions drawn by Kubala and Kellaway, (1967 cited in Klonoff, et al, 1977) and Rodin (1967). However, the literature is not unanimous with regard to the predictive power of the EEG record: Silverman (1966, cited in Craft, 1972) has noted an excellent correlation between degree of injury and abnormality of the electro-encephalogram, but he has also recorded the presence of marked abnormality in some children with minor injury and Richardson (1963) found no simple correlation between EEG abnormality and behavioural or intellectual sequelae.

4 Cognitive sequelae

4.1 Overall intellectual outcome

Research has frequently reported intellectual deterioration following severe closed head injury during childhood. Hjern and Nylander (1962) following up 22 severely head injured children between 6 months and 9,5 years after injury found that

41% of the sample were intellectually retarded. Richardson (1963) compared the results obtained by ten very severely injured subjects, 2 to 13,5 years after injury, with pre-injury school records, previous intelligence quotients and parental observations and found a 10 to 30 point drop in overall intellectual ability. Brink, et al, (1970) noted, after testing 52 very severely injured subjects, aged 2 to 18 years at injury, on Wechsler and Stanford-Binet scales one to seven years post-injury, that 33% fell in the normal range of intellectual functioning (IQ above 85), 30% were of borderline intelligence (IQ of 70 to 85), 23% were mildly retarded, 9% were moderately retarded and 5% were severely retarded; in all, 37% of the sample tested with IQ scores below 70. In fifteen cases where previous test results could be obtained, a drop of at least 10 points in global score was noted. A positive correlation between duration of coma and global score was found. In a follow-up of severely injured children 8 to 10 years post-injury, Flach and Malmros (1972) found that nearly 50% of the sample manifested overall intellectual deficit and that the most severe deficits occurred in Performance subtests.

Levin and Eisenberg (1979a) found that overall IQ scores falling more than one standard deviation below the population mean (i.e. less than 85) were common among patients who sustained a very severe injury (coma duration of more than 24 hours) when tested approximately one year after injury.

No patients in the category defined by coma of less than 24 hours scored below 85. Levin and Eisenberg (1979b) concluded that although the level of global IQ was well within normal limits in all but the most severely injured patients, only partial recovery was achieved when the results were compared with previous scores.

In their prospective study of severe and mild closed head injury (severe defined as post-traumatic amnesia of more than seven days), Chadwick, Rutter, Brown, Shaffer and Traub (1981) conclude that both verbal and performance IQ were lowered by severe injury, but performance IQ was most affected. At the final follow-up in the study ($2\frac{1}{4}$ years after injury) all but one of the most severely injured patients (PTA lasting longer than three weeks) showed persistent impairment on all aspects of intellectual functioning, persistent impairment being associated with continuing neurological deficit. There was an important deficit in visuo-spatial (performance tests), but even the verbal IQ score of the WISC was lowered by 14 points at the one year follow-up. Less severe head injury (defined as post-traumatic amnesia of two to three weeks) resulted in an initially less marked and less persistent impairment, but at final follow-up a 14 point deficit in performance IQ was recorded, complete verbal recovery having been noted in this group at one year. Still less severe injury, defined by PTA duration of one day to two weeks resulted in initial lowering of IQ and generally in no significant final deficit although transient deficit in performance IQ was found and, in some cases, lowered global IQ occurred at final assessment.

In adults, a similar pattern is found: lowering of the global IQ score is found immediately and may be permanent. Residual deficits are more likely to be found in performance tasks, the extent of the residual deficit depending on the initial global impairment which is considered to be a good index of severity of injury (Mandleberg and Brooks, 1975; Becker, 1975; Dikmen, Reitan and Temkin, 1983). Specific neuropsychological deficits in adults following closed head injury have been found in memory, language, visual perceptual functions and behavioural disturbance (Levin and Eisenberg, 1979b).

4.2 Specific Neuropsychological Deficits

4.2.1 Language

Impairment in language functions following severe injury in childhood has been documented by a number of researchers. Naughton (1971) found deterioriated language skills and difficulty in relearning them in a follow-up of 46 children surviving a severe head injury. Fuld and Fisher (1977) noted receptive language difficulties and dysfluent language with occasional paraphasias in their study of seven children severely and very severely injured. Levin et al, (1979a) found deficient performance in 33% of 45 cases tested between two days and three years after injury. These deficits were found in expressive language subtests in which subjects were required to name objects presented visually or tactually and in writing, and in receptive language tests in which subjects were required to manipulate tokens of varying shapes, colours and sizes following nonredundant oral commands. In a second paper published in 1979, Levin, et al, using the above tests, found anomia for objects presented visually in 13% of cases studied and in 12% of cases in which objects were presented tactually to the left hand. Comprehension of oral language was disturbed in 11% and verbal repetition was the area found to be least frequently affected, disturbance noted in only 4% of the sample.

Chadwick, et al, (1981c), made a similar finding: i.e. lowered speed in naming objects in a test in which the children were required to name ten pictures of common objects as quickly as possible.

4.2.2 Memory

Few studies have assessed the memory capacity of head injured children, but all have reported impairment and suggest that this is one of the most seriously impaired functions post-injury (Levin, et al, 1982). Richardson (1963) noted that performance in his study of ten closed head injury cases was consistently lowered in tests dependent on rote memory and Naughton (1971) noted that subjects experienced difficulty in situations requiring normal retention. Fuld and Fisher (1977) reported loss of long-term memory capacity following severe injury and demonstrated some recovery in a case study in which the child was tested repeatedly with the Buschke (1973, 1974) selective reminding method. This method separates and gives scores for long-term storage and retrieval and short-term recall. Using this technique, Levin et al, (1979b) found that memory deficit occurred in at least 33% of cases, memory deficits being amongst the most common findings. In their second paper Levin, et al, (1979a) again found that memory was the most frequently impaired function in the group of patients tested: 50% were deficient in tests using selective reminding and/or the continuous recognition test which is non-verbal. Storage and retrieval deficits were found in children and adolescents who recovered consciousness after coma of less than 24 hours duration, more severe deficits being found in the more severely injured patients (who were comatose for longer than 24 hours) who displayed impaired verbal retrieval and lowered continuous recognition memory two years after injury, (Levin, Eisenberg, et al, 1982).

4.2.3 Visuo-spatial functioning

Flach and Malmros (1972) reported that 24% of their sample had visuo-spatial disturbances and Naughton (1971) noted that many of the children studied experienced difficulty in situations requiring quick perception. Fuld and Fisher (1977) have also reported visuo-spatial deficit following head injury. Levin, et al, (1979a and b) recorded visuo-spatial deficit in at least 33% of cases studied, visuo-spatial and visuo-motor abilities having been evaluated by the copying of geometric designs (Bender Gestalt test), construction of block designs using three-dimensional models (Benton and Fogel, 1962, cited in Levin, et al, 1979b) and discrimination of photographs of faces (Benton and van Allen 1968, cited in Levin, et al, 1979b), the cases having been assessed in a time range from one day to approximately three years post-injury. Twenty percent of cases displayed defective performance on the Bender Gestalt test, a rate which was twice as high as that displayed by other measures of visuo-spatial functioning. Chadwick, Rutter, et al, (1981b) record that visuo-spatial skills tended to be the most severely affected group of functions in the more severe series of cases, initially post-injury, at one year and at final ($2\frac{1}{4}$ year post-injury) follow-up. In less severe cases visuo-spatial deficit was present initially but tended to be transient and have recovered by final ($2\frac{1}{4}$ year) assessment.

4.2.4 Motor-Speed and Concentration

Deficit in motor speed is one of the most common findings in the assessment of a child following severe head injury. Naughton (1971) found that many children in the series studied experienced difficulty in situations requiring sustained attention and concentration. Levin and Eisenberg (1979b) found that motor proficiency was lowered in at least 33% of the patients in their series, adolescents being assessed on apparatus evaluating response latency in switching off a stimulus light using a telegraph key located below it and younger children were tested by means of timed finger-thumb opposition. In their second paper Levin and Eisenberg (1979a) found that 22% of the group studied had lowered motor proficiency. There was a trend for increased frequency of deficient motor proficiency in the more severely injured patients. Chadwick, et al, (1981c) report that at one year and final follow-up of their groups, besides deficient object naming, subjects displayed lowered performance in tests of manual dexterity, finger-tapping and reaction time, i.e. short-timed tests required quick motor response.

4.2.5 Somatosensory functioning

Somatosensory perception and appreciation of body schema were assessed by tests of stereognosis using sets of textured geometric designs (Benton, 1969), finger localisation (Benton 1959) and graphesthesia by Levin and Eisenberg (1979a and b). They found that in the one group (1979b) performance was impaired in at least 33% of patients, and in the other 24% of the series was impaired. In the most severely injured patients 36% performed at an impaired level and there was a trend for greater impairment among the most severely injured.

5 Psychiatric Sequelae

Hjern and Nylander (1962) found that 27% of the 22 cases they studied displayed psychiatric sequelae between 6 months and 9½ years after injury. Richardson (1963), from information given by teachers, revealed that distractability, poor comprehension and concrete perseverative performance were characteristic of children post head injury. Subjective impairments noted by Richardson included anxiety, irritability, difficulty in sustaining concentration and rapid onset of fatigue. In their study of children in coma for over one week and followed up one to seven years post-injury, Brink, et al, (1970) found that younger children (under 10 years old at injury) tend to be hyperactive, have decreased attention span, throw tantrums and are aggressive, destructive, impulsive and enuretic; on the other hand, older children (over 10 years old at injury) tend to display poor social judgement and affective disturbance. Black, et al, (1971) have indicated that the most common symptoms following head injury are headache, over- and under eating, hyperkinesis and lowered attention span. Less commonly, irritability, temper outbursts, major disciplinary problems (e.g. stealing, fire-setting), sleep disturbance and hypokinesis are found. Naughton (1971) has described decreased alertness and self-control. Brink, et al, (1980) found that 46% of the severely injured cases they studied were severely emotionally disturbed, displaying symptoms of emotional liability, social withdrawal, delusional ideation, paranoia, confusion, phobias, acting out impulsive behaviour and lowered tolerance of frustration.

In a recent British study, Brown, _et al_, (1981) reported that the rate of the development of psychiatric disorder after injury was found to be 53,3% in children under 10 years and 45,4% in children aged 10 years and older. They noted no distinct pattern of psychiatric disturbance post-injury, but they did find that the most severely injured patients (PTA duration of longer than 22 days) in the series they studied tended to display socially embarrassing behaviour with disinhibition and disregard for the social environment (i.e. over-eating and over-talkativeness), bed-wetting, general slowness, speech abnormality, decreased cooperation and distractibility. The only significant symptom found in children whose PTA was less than three weeks in duration was yawning. No evidence of psychiatric disability was found where PTA lasted for less than one week.

As Shaffer, _et al_, (1975) have indicated, it would appear from the literature that the group of children who suffer closed head injury may manifest a full range of psychiatric disturbance post-injury. Brown, _et al_, (1981) found that neither physical disability, age or sex influenced the risk of developing a psychiatric disorder following severe head injury. However, they did note a modestly positive relationship between severity of head injury and rate of development of psychiatric disorder, a finding which agrees with that of Shaffer, _et al_, (1975). Furthermore, the authors observed that new psychiatric disorders after injury were much more common in severely injured children without neurological or cognitive impairment than in controls. Brown, _et al_, therefore suggest that the effects of brain injury in giving rise to a psychiatric disorder may operate through indirect as well as direct (structural tissue damage) mechanisms.

It has been well demonstrated that children who suffer accidents are more likely than other children to show behavioural deviance prior to the accident and to come from homes with various forms of psychosocial adversity. (Craft, et al, 1972, Brown and Davidson, 1978 cited in Brown, et al, 1981). Black, et al, (1969) have reported that, prior to injury, approximately 33% of children in the series studied exhibited at least one of the major symptoms found post-injury, Shaffer, et al, (1975) found that over 40% of the children in their study came from either broken or unhappy homes, 44% had mothers with a significant emotional disturbance and 33% came from homes with four or more siblings. Seidel, et al, (cited in Shaffer, et al, 1975) have indicated that over-crowding is a further adverse factor. Psychosocial adversity was defined by Brown, et al, (1981) as two or more of the following factors:

a. child not living with natural (i.e. biological or adoptive) parents or parental marriage rating indicating poor or very poor quality;

b. siblings of at least four children or a person-room ratio exceeding one;

c. admission of the child into the care of the local authority because of family difficulties;

d. socially handicapping psychiatric disorder in mother;

e. paternal criminality;

f. father with unskilled or semi-skilled job.

Brown, et al, (1981) found that children with disorder preceding the accident were likely to continue to show problems after the injury and of children without prior abnormality 28,6% showed definite psychiatric disorder at one year follow-up. Black, et al, (1969) reported that approximately 20% of children with pretraumatic symptoms developed new symptoms or an aggravation of pre-existing behavioural traits. Of children who were normal before injury, 20% developed behaviour disturbance post-traumatically.

From these results, Brown, et al, (1981) have concluded that psychiatric outcome following closed head injury in childhood is a function of pre-injury behavioural characteristics together with the severity of the head injury and the presence of psychosocial adversity.

Given the frequency of cognitive deficit and scholastic failure following closed head injury in childhood and noted elsewhere in this chapter, a further aetiological mechanism possibly underlying the evolution of post-traumatic psychiatric symptoms may be found in the relationship which has been frequently demonstrated between educational backwardness and psychiatric disturbance (Rutter, et al, 1970).

Naughton (1971) has emphasised the importance of parental influence on the recovery of the head injured child. Gallagher (1957, cited in Shaffer, et al, 1975) has pointed out that injured children tend to be more demanding and impulsive which behaviour generates hostility in the family leading to the development of more complex deviant behaviour. Hjern and Nylander (1964) found that post-traumatic psychiatric sequelae were reported in 17% of children whose mothers were given a vague non-committal less optimistic prognosis in comparison with a rate of 6% of children whose mothers were told that the injury was not serious and the prognosis good.

6 Factors Affecting Recovery

6.1 Time course of recovery

Klonoff, et al, (1977) have demonstrated that children who have sustained a severe closed head injury recover over time. Children in the study were assessed immediately post-injury and then annually for five years. They found that 76,3% of patients made a marked recovery over the time period, which improvement extended over the whole five year period follow-up. All subjects were found to have very pronounced effects immediately post-injury which deficit decreased markedly, i.e. by the five year follow-up most were recovered; 23,7% of the sample were still impaired. Electroencephalographic ratings recovered most rapidly and were found to be a stable indication of return to normal. Klonoff found full scale IQ score predictive of potential residual sequelae: full scale IQ should increase discernibly if recovery is occurring. Klonoff points out that increase in operational IQ as a measure of recovery rate is in agreement with the findings of Brink, et al, (1970), Black, et al, (1971) and Mandleberg and Brooks (1975).

Black, et al, (1971) delineates an overall time-course of recovery for the head injured child in his study of 105 children who were 0 - 14 years of age at the time of injury. He found that neurological deficit was present in 24% of the sample on discharge from hospital which, at that point, represented a decline from 34% on admission; at three month follow-up the incidence was found to be 15%, at which frequency it stabilised. Behaviourally, an increase in the incidence of hyperkinesis was found during the first few months after injury, the incidence thereafter declining steadily and levelling off between three and five years post-injury. There was a similar decrease following an initial rise in incidence of hypokinesis. The decline in the incidence of abnormal kinesis in the direction of premorbid levels approached statistical significance. Poor control of affect (crying, screaming, mood swings) persisted for two years before subsiding to a level slightly higher than that found at pre-injury status. Severe behavioural problems (i.e. destructiveness, stealing and fighting) were found to follow a similar post-traumatic course, with an unexplained upward swing at the four to five year assessments. Intellectually, intelligence scores for the group (measured by the WISC) improved slightly each year, the degree of improvement approaching statistical significance.

In their study of severe and mild closed head injury in childhood, Chadwick, Rutter, Brown, Shaffer and Traub (1981) found that the mildly injured group did not show any cognitive gains on follow-up. However, the severe group showed gain in cognitive function on all measures except the Vocabulary and Digit Span subtests of the WISC that was significantly greater than that shown by a control group of orthopaedic controls between the initial and one year post-injury assessments. The verbal deficit was less severe initially in the severe group and at the one year assessment verbal recovery was found to be more complete than that shown by visuo-spatial skills. Thus, initially and one year after injury, performance IQ was found to be significantly depressed. Where injury was most severe (three weeks duration of post-traumatic amnesia) deficits in all aspects of intellectual performance were found at the final follow-up ($2\frac{1}{4}$ years after injury). PTA of two to three weeks was associated with complete recovery of verbal IQ at one year and performance IQ deficit at two years. PTA of 0 - 2 weeks was associated with transient impairment and in most cases complete recovery by the $2\frac{1}{4}$ year follow-up. Most recovery was found to take place in the first four months after injury was sustained.

A similar pattern of recovery to that described by Chadwick, et al, (1981b) has been found by Mandleberg and Brooks (1975) in their study of recovery from head injury in adults. They record that there is substantial recovery in the first year after injury, particularly in the first six months, after which improvement rate levels off. Mandleberg and Brooks also found that in adults verbal recovery takes place more rapidly than that of non-verbal functions.

6.2 <u>Age</u>

As indicated earlier in the chapter the mortality rate among children is accepted as lower than that of adults after severe cerebral trauma (Carlsson, <u>et al</u>, 1968). Black, <u>et al</u>, (1981) suggests that this is also the case in terms of morbidity, although Levin, <u>et al</u>, (1982) note that the cognitive functioning of adults and children following severe closed head injury has not been directly compared. On comparison of intellectual and memory function in children under twelve and adolescents over twelve years following severe injury, Levin, <u>et al</u>, (1982) found no evidence to suggest that functions are spared in the younger brain; in fact it was found that global intellectual deficit was confined to patients younger than thirteen years at time of injury. Brink, <u>et al</u>, (1970) have come to similar findings: in their study global IQ results in younger children (under six years) were found to be significantly lower than those of older children (over ten years) following closed head trauma.

Much of the argument for a better outcome in children when compared with adults has rested on the concept of cerebral plasticity which suggests that the younger and developing organism is more able to transfer functions from damaged to intact parts of the brain, and in this way functions are not eliminated by tissue damage. The argument for plasticity has been critically discussed recently by Bishop (1981) and Robinson (1981) the latter stating that ...

> 'the trauma literature in general lends no support to the notion that the child can escape with greater facility than the adult ... in children, when the brunt of damage is in the left hemisphere, subsequent verbal performance suffers. Conversely, when the right hemisphere is damaged visuo-spatial difficulties can be expected. When trauma is accompanied by cerebral haemorrhage the outcome is equally bad in the child as in the adult. Thus when the site, nature and severity of the injury are comparable, the child appears to suffer equally with the adult.' (p 381)

Much of the plasticity argument has developed from Basser's (1962) work suggesting that children are able to transfer language from a focally damaged left hemisphere to an intact right hemisphere as well as effect intrahemispheric re-organisation. (Cited in Robinson, 1981). While this may be so, Levin, et al, (1982) and Bruce's comments at the end of their paper make the clear point that where diffuse damage secondary to closed head trauma is being discussed the damage is primarily bilateral and the child's brain does not have the opportunity and is unlikely to be able to transfer function when the structure of the whole brain is affected. In fact, Bruce suggests that it is the very lack of focal specialisation in childhood, allowing for transfer of function after focal head injury, that results in a comparable if not less effective recovery from diffuse head injury in children when compared with adults and adolescents.

Rutter (1981) has pointed out that the above issue applies only to the broad spectrum of age in head injury, i.e. age differences concern disparity in outcome between childhood, adulthood and old age rather than differences within childhood years. Lutz (1951, cited in Black, 1981) has reported that severe injury before the age of three years leaves more serious residua in the child than a comparable injury occurring later. Mahoney, et al, (1983) have argued that the mortality rate in children under five years is higher than that of children over five. Rutter (1981) explains such results by reviewing Dobbing's (1938) argument that children prenatally and two years postnatally are far more vulnerable to the effects of trauma because this is the time of most rapid growth of the nervous system.

6.3 Severity of injury

6.3.1 Duration of coma

The literature has almost consistently found a link between duration of coma and severity of injury. Åkerlund (1959) found that loss of consciousness of up to four weeks duration resulted in 'good restitution' in two-thirds of the cases he studied, whereas where unconsciousness lasted more than four weeks, severe residual deficits were found. Brink, et al, (1970), Shaffer, et al, (1975) and Bruce, et al, (1978) have all found a positive correlation between duration of coma and lower IQ results. Heiskanen and Kaste (1974) have indicated that loss of consciousness for two weeks may be regarded as a cut-off point: from their research they suggest that it is unlikely that a child will make normal progress after coma of this or greater length. Stover and Zeiger (1976) however, noted that no patient in coma for longer than seven days made a good recovery. Coma under thirteen weeks duration was consistent with the presence of permanent mental and physical sequelae, but the patient was ambulatory and generally independent. Prognosis was less favourable with coma of over thirteen weeks duration and coma lasting longer than four months generally resulted in a dependent outcome, i.e. the patient was non-ambulatory and lived in a persistent vegetative state. Comninos (1979) found that "good recovery" was consistent with a coma duration of under three days, "moderate disability" could be expected with a length of coma of more than one week and "poor outcome" was linked with a coma duration of longer than two weeks. Levin, et al, (1979a) found a consistent link between magnitude of deficit and increasing duration of coma. Neuropsychological residua were found in the early post-traumatic period where coma was less than twenty-four hours in length and a persistent fall-off in global IQ was found after a long post-injury interval in patients who were in coma for twenty-four hours or longer. Levin, et al, (1979b) found that duration of coma was significantly associated with degree of visuo-spatial deficit. Black, et al, (1981) records an association between duration of loss of consciousness and fall-off in global IQ as well as behavioural difficulties post trauma. Brink, et al, (1980) noted that independence in ambulation and self-care was present in 94% of patients with a coma duration of less than six weeks, 76% of patients whose coma lasted from six to twelve weeks and in 38% of patients whose coma lasted for longer than three months. The reduction in frequency of this level of outcome as coma duration increased was significant. Spasticity and ataxia were found to be more severe with increasing length of coma. The literature thus indicates that the longer the duration of coma, the more severe the long-term sequelae of the injury are likely to be and Levin, et al, (1982) have reported that the duration of loss of consciousness is prognostically more important than the depth of coma measured by the Glascow Coma Scale Score on admission.

6.3.2 Depth of coma and neurological status on admission

Bruce, et al, (1978) consider the neurological state of the patient on admission to be a major factor in prognosis. The Glascow Coma Scale Score on admission has been found to be an important indicator of level of prognosis by a number of researchers. Comninos (1979) has recorded that patients with a Glascow Coma Scale score of 1 - 3 died, those with a score of 3 - 5 survived with moderate to severe disability and those with good outcome had a score above 5. Braakman, et al, (1980) have noted that, initially, the motor score of the Scale is the most important prognostic indication, followed later by the verbal score. Levin and Eisenberg (1979a) have noted that disruption of the motor and verbal scores of the Glascow Coma Scale is associated with increased probability of neuropsychological deficit. Levin and Eisenberg (1979a) further note that a lowered verbal score is associated with lowered performance in visuo-spatial and memory tasks.

Abnormal motor patterns following head injury include typical decerebrate rigidity (extension of extremities, clenching of hands, pronation of upper extremities, hyperventilation, sweating, and/or spontaneous extension of the big toes), atypical decerebrate rigidity (all other abnormal motor responses) and hypotonia (Overgaard, et al, 1973, cited in Dye, et al, 1979).

Bilaterally negative pupil reaction to light carries a negative prognosis. Spontaneous eye movements or the inter-related reflex eye movements (oculocephalic and oculovestibular responses, both measures of brain stem dysfunction), are regarded as important indicators of a poorer prognosis. A pattern of deterioration in the level of coma together with the presence of apnea and extracranial complications are also important indicators for negative prognosis. (Teasdale, et al, 1979, cited in Braakman, et al, 1980).

6.3.3 Duration of post-traumatic amnesia

Post-traumatic amnesia has been described as a more powerful predictor of cognitive outcome than duration of coma (Brooks, et al, (1980)). Brooks and Aughton (1979) found a negative association between memory test scores and PTA within two years of injury. Mandleberg (1976) found that increased duration of PTA was associated with reduced Performance IQ up to six months and with reduced verbal IQ up to three months post-injury in adults. In this study the association between PTA and cognitive impairment after six months was only a trend. However, Chadwick, et al, (1981b) reported that duration of PTA for longer than three weeks was associated with persistent impairment on all aspects of intellectual functioning at follow-up, such persistent impairment being associated with continuing neurological deficit. PTA of two to three weeks length was associated with less marked, less persistent impairment and PTA of nought to two weeks duration was associated with no significant deficit at final follow-up. Brown, et al, (1981) found that whereas only yawning was significantly associated with a PTA of one to three weeks, PTA of three weeks and longer was associated with speech abnormality, decreased cooperation, distractibility and increased social disinhibition.

6.4 Complications

Using broad categories of outcome, Bruce, et al, (1978) have indicated that the presence of mass lesion does not influence outcome. However, Becker, et al, (1977) have noted a higher mortality rate in patients with a midline shift of more than 10mm caused by mass lesion, compared with those with a shift of 9mm or less and Stover and Zeiger (1976) have noted that patients with traumatic subdural haemotoma were among the most cognitively impaired within each broad category defined by length of coma. The laterality of haemotoma has been found to be unimportant (Brooks, et al, 1980). Bruce, et al, (1978) note that in their series and in others, diffuse brain swelling has been the commonest clinical finding in children dying from head injury. Miller, et al, (1977) have noted that mortality rate rises with increase in intracranial pressure. Overgaard (1973) has recorded that regardless of age, systolic blood pressure of more than 160mm Hg in the first three days following injury is associated with severe deficit later. Skull fracture and its laterality has been found to have little effect on outcome (Brooks, Aughton, et al, 1980).

6.5 Site of impact

Chadwick, Rutter, Thompson and Shaffer (1981) studied a group of ninety-seven children, aged two or less at time of injury, at least two years after injury, each of whom had sustained a unilateral compound depressed fracture of the skull resulting in a tear in the dura and with gross damage to the underlying brain observed at operation. Of the sample, 51,6% had a history of loss of consciousness ranging in duration from less than thirty minutes to seven days or more. They found that neither the child's age nor the hemisphere damaged was of importance in assessment of cognitive outcome. However, cognitive performance was significantly associated with the overall severity of brain injury as reflected in the duration of loss of consciousness and treatment for cerebral oedema, the effects of trauma tending to be more marked in visuo-spatial and visuo-motor skills than verbal skills as has been reported earlier in this chapter. The relative lack of importance of focal damage suggested by Chadwick, et al, has also been reported by Mandleberg and Brooks (1975) who found a pattern of bilateral damage in adults despite the number of patients injured on the left, which is explained by the contrecoup effect together with secondary brain disruption by ischaemic damage and characteristic white matter degeneration in blunt injury. It would thus seem, as Levin, et al, (1982) has pointed out, that it is the severity of diffuse injury rather than the presence of lateralisation of a focal lesion which is the primary determinant of cognitive recovery in closed head injury.

7 Overall Pattern of Residual Sequelae

Klonoff, Low and Clark (1977) found that, of 43,6% of the sample displaying neuropsychological, electroencephalographic and neurological impairment, 1,7% were impaired in three areas, 12% were impaired in two areas and 29,9% were impaired in one area only. They conclude that the results generally indicate that long-term effects of head injury may be qualitatively different for some children in terms of area affected and in some children these effects are generalised.

8 Social Outcome

Bond (1975) proposed that six areas be considered in a scale of social recovery following head trauma: return to work, family cohesion, leisure, criminality, sexual activity and alcohol consumption. In terms of children, the literature has commented on the effects of head injury time elapsed before return to school (in place of return to work) and family functioning. The previous section on psychiatric outcome commented on severe disciplinary problems, and activity which may be considered socially inappropriate.

8.1 Return to school

Naughton (1971) has noted that, as a group, cases with prolonged unconsciousness have the poorest prospects although three children out of seven in the survey returned to school between one and two years after injury. Vapalathi (cited in Leary, 1982) has stated few children whose period of unconsciousness exceeds two weeks are able to resume normal education, whereas most of those who are unconscious for a lesser period eventually return to ordinary school. Heiskanen and Kaste (1974) have reported that, of thirty-six children who were unconscious for longer than twenty-four hours, 22% were unable to continue in a normal school routine, 25% were in normal school but performing poorly and 47% were making average progress. Naughton's (1971) survey found that 50% of severely injured children had returned to school within one year and more than 66% within two years. However, researchers have also noted a high rate of scholastic failure, transfer to special education programmes and need for remedial lessons in children who have returned to school following closed head injury (Brink, et al, 1970; Klonoff and Clark, 1977, cited in Levin, Benton and Grossman, 1982). In adults, delayed return to work has generally been a function of inadequate personality functioning, impaired cognitive function (particularly impaired memory) and physical incapacity (Bond, 1975; Wedell, Oddy and Jenkins, 1980) and Oddy and Humphrey (1980) note that premorbid personality characterised by nervousness and suspiciousness was also a delaying factor. In children, of cases taking up to two years to return to school, many had verbal deficits. Richardson (1963) has noted deficits in reading tasks at follow-up and Naughton (1971) has reported loss of language skills and difficulty relearning them, together with retention difficulties and loss of sustained attention and concentration, rapidity of perception and decreased emotional control noting that these may clearly be disabling in the classroom. Naughton (1971) further notes that preliminary home teaching and an adjustment of class are useful adjuncts to employ where a child suffering from the above difficulties requires special attention and simultaneously may benefit from the social opportunities of attendance at a normal school. In some cases deficits may be so severe that return to a normal school is not possible and special schooling is required. Naughton points out that a rough index of the rate and extent of subsidence of post-traumatic sequelae is the time that elapses before the child is able to return to school, which is a more exacting criterion of recovery than return to employment is for an adult: schools demand efficient performance of set tasks which are more regularly and objectively assessed than in many jobs. However, Naughton suggests that it is not generally practical or socially desirable to await full recovery before the child returns to school. In Naughton's view education constitutes the final phase of rehabilitation and is most likely to do so if a child's teacher is adequately informed about the presence of deficits and difficulties.

8.2 Family Functioning

In a follow-up of children who had suffered closed head injury carried out by Klonoff and Low (1974, cited in Levin, Benton and Grossman, 1982) it was reported that deterioration in the relationships of the children occurred primarily in the home, at the rate of approximately 10% of the children in the first year post-trauma and about 5% in the second year.

Thomsen (1974), Panting and Merry (1972) and Bond (1975) have all indicated that mental and personality changes carry more stress for the family than physical disabilities although Naughton (1971) has pointed out that parental management may be unduly stressed by conspicuous disfigurement, e.g. a skull defect. The above authors have further noted that a parent-child relationship is better able to withstand the stresses brought into the family by a recovering child than a marital relationship in which one of the spouses is the injured subject. The dependent child-parent relationship is an old and familiar one in the family and roles are likely to readjust more easily than they would in a marital relationship in which the spouse-caretaker has to cope with a personal loss of a different extent and quality. Gogstad and Kjellman (1976) have pointed out that good family relationships are very important for successful rehabilitation. Naughton (1971) has made the same point: parental attitudes implying realistic handling of the head injured child are influential in promoting recovery. Such attitudes and handling are likely to depend on the family members having made and accepted a realistic appraisal of the child's current deficits and expected recovery. In order to make such an appraisal the family requires information. Oddy, Humphrey and Uttley (1978) have commented that 25% of relatives of head injured patients studied were under significant stress not only due to the patient's personality change and the relatives' own perceptions of the symptoms arising from the head injury, but also because they had been given insufficient information regarding the patient's condition and prognosis, with particular reference to the future courses of personality changes. Brooks and Bond (1976) have commented that family tensions are often needlessly high. Romano, (1974) has indicated that, in some cases, the attitudes of families may take a pathological form, with denial of the seriousness of the patient's disability, inability to accept that further recovery is unlikely and even rejection of the injured person.

8.3 Peer relationships

Among adults suffering head injury, Bond (1975, 1976) has indicated that apart from work activities, leisure activities are the most disrupted areas of daily life. Thomsen (1974) has indicated that the main problem mentioned by adult patients one to six years after injury was lack of social contact. Hpay (1971) recorded that 21% of injured adults suffered obvious change in social life and a further 14% became social outcasts primarily as a result of personality changes. This situation is unlikely to be different among children particularly if they are withdrawn, hyperactive or aggressive.

9 Summary

Research to date has indicated that closed head injury during childhood may result in physical and neurological abnormality, neuropsychological deficits and psychiatric sequelae. The injured individual may manifest impairment in two or all three areas concurrently; however, many present with abnormality in only one area post-traumatically. Physical and neurological sequelae include epilepsy, dysphasia, hemianopia and hemiparesis as well as bilateral spasticity, dysarthria and cerebellar ataxia. Neuropsychological deficits appear to occur most frequently in the areas of memory, motor and visuo-spatial functioning. The group of children who suffer closed head injury may manifest a full range of psychiatric sequelae post-injury, but some post-traumatic symptoms which occur frequently are headache, hyperkinesis, distractibility and social disinhibition.

It would appear that sequelae are found to be more severe as the duration of coma and post-traumatic amnesia increases. Recent research has indicated that permanent cognitive impairment is most likely to be found where the duration of post-traumatic amnesia has exceeded three weeks. Less favourable outcome has also been linked with lower level of consciousness on admission to hospital immediately following the occurrence of the injury. The site of the impact and the presence of skull fracture appear to have little influence on outcome following closed head injury. Where psychiatric sequelae have been studied, researchers have concluded that while the severity of the injury is related to the development of new symptoms post-traumatically, the presence of psychosocial adversity and the pattern of pre-injury behavioural characteristics are important aetiological factors where they are considered in combination with each other and the severity of the injury. Impairment in all areas tends to be most severe immediately post-injury, recovery occurring for up to five years post-trauma.

Recent research has suggested that there is no apparent sparing of function following closed head trauma and diffuse brain injury in children compared with adolescents and adults; however, younger children appear to be more vulnerable to the effects of the trauma than older children.

Return to school has been considered to be an exacting indication of the rate and extent of subsidence of post-traumatic sequelae. However, many severely injured children experience serious scholastic difficulties once they have returned to school. Mental and personality changes in the child and a lack of adequate information about prognosis are regarded in the literature as the most frequent sources of stress for relatives and the child's relationships within his family.

CHAPTER THREE

THE PSYCHOLOGICAL ASSESSMENT OF CLOSED HEAD INJURY

1 Aim

The psychological assessment of a child after he has sustained a severe head injury has one major aim: the evaluation of the extent of change (if any) in two areas -

(1) intellectual, scholastic and neuropsychological functioning, and

(2) behavioural, emotional and social factors.

The clinical psychologist has a number of methods which he may use and sources on which he may call to fulfil the above aims with reasonable accuracy. This chapter will review the nature of the sources and selected useful methods which may be used to obtain the information required by the psychologist in an assessment.

2 Sources

Sources to be tapped in the assessment include people who are in direct contact with the child with sufficient frequency to be able to comment with accuracy on important aspects of his daily functioning: parents, siblings, other close relatives and teachers, as well as the child himself, are important sources of information which is usually gathered by means of careful, systematic interviewing. As is clear from the research results presented in the previous chapter (Levin and Eisenberg, 1979a and b, Levin, et al, 1982, Chadwick, et al, 1981a) very important data is to be gained from the use of neuropsychological tests. Frequently, an outcome which is defined by some as 'good' (i.e. the child is able to care for his own hygiene and is able to walk) in fact masks specific neuropsychological deficits which, for example, have a significant effect on the child's ability to cope scholastically (Levin, Benton and Grossman, 1982).

3 Methods

3.1 Interviewing

Information should be obtained from three primary sources: parents and relatives, teachers and the child himself.

3.1.1 Parents and Relatives

3.1.1.1 Areas in which information should be obtained

This interview should gather data that is related -

(1) to the psychosocial background from which the child comes, and

(2) to specific details personal to the child.

Information obtained under (1) should include details about the child's parents (their level of education and the type and stability of their occupations), siblings (their ages, scholastic progress and occupations), family relationships, income, type of housing, number of people living in the house (with details of person-to-room and person-to-bed ratios), community resources, after-school care, family health history (both physical and psychiatric) and familial leisure activities. The possible presence of social problems (alcoholism and criminality), neglect and abuse of the child and the involvement of a welfare organisation in the family should be investigated. In gathering specific details about the child's personal history, care should be taken to obtain a clear picture of the child's emotional, behavioural, scholastic and social adjustment prior to injury, followed by one post-injury, noting changes where they have occurred. Apart from this information, the cause and circumstances of the head injury and the child's immediate recovery should be discussed, together with details about the child's birth, development and health prior to the injury. An uncomplicated birth history, followed by normal milestones and absence of accident or severe illness prior to the head injury will suggest normal development; the psychosocial background data together with personal information will give an indication of the potential future functioning of the child had he not been injured.

Psychosocial background data also provides information for the assessment of psychosocial adversity, the importance of which has been emphasized by Brown, et al, (1981) in their research into psychiatric outcome following closed head injury.

3.1.1.2 <u>The Interview Format</u>

Standard formats exist for interviewing the parents of children referred for general psychiatric intervention. While these formats are comprehensive and useful, their primary function is to guide the interviewer, given the presentation of any one of a range of psychiatric problems which may appear during childhood. Their function is therefore to assist the clinician in the description, labelling and exploration of the reasons for the presence of abnormal behaviour in a child. However, in the assessment of a child who has sustained a severe closed head injury, the task at hand is somewhat different: the primary focus is on head injury as a specific aetiological factor, the question being whether or not abnormal functioning is evident in its wake. Thus the question asked in the assessment of the head-injured child: 'What are the consequences of this event, if any?' is the corollary of that asked in the general psychiatric assessment interview: 'What are the reasons for this behaviour, if it may be assessed as abnormal?' Given the above argument, the development of a specific format for an interview with the parent of a head-injured child would seem to be justified. Further support for a specific format is given by its simplification of the interview: checklists of common symptoms following severe closed head injury may be included and indications made where the child's functioning pre- and post-injury must be differentiated. Another consideration is the finding of Graham and Rutter (1968) that where an accurate description of a child's behaviour is being sought, non-directive interviewing of the parent is frequently inaccurate; they found that mothers were inconsistent in their assessment of their child's disturbance when interviewed on two separate occasions and that for all symptoms but one (temper tantrums) symptoms were more often elicited by direct questioning than described spontaneously.

For these reasons an interview format for specific use in interviewing the parents and relatives of a head-injured child was developed for use in the research reported in the following chapter (Appendix A). It is divided into three major sections: A - data pertinent to the head-injured child; B - information about the family and

C - data specific to the social circumstances of the family. Areas which must be explored for changes following injury are clearly marked. The psychologist may find it useful to employ other rating scales of childhood behaviour in conjunction with the basic interview. Two such scales are those developed by Rutter, Graham and Yule (1970) and Conners (1973).

3.1.1.3 Child Scale A(2) (Rutter, Graham and Yule, 1970)

This quickly administered and easily scored scale is made up of thirty-one brief statements concerning the child's functioning. The three sections deal with health problems, habits and behaviour respectively, each section grading the response on three points each given a score (0, 1, 2). When the scale is complete, a score in the range 0 - 62 is computed, some disorder indicated in children scoring 13 or more (Rutter and Graham, 1968). Where the score for typically neurotic symptoms exceeds that for typically antisocial symptoms, the child is described as neurotic and vice versa. The scale is an improved version of a previous scale (A) which was found to discriminate between a clinic and non-clinic sample of children (Rutter, *et al*, 1970).

3.1.1.4 Parent-Symptom Questionnaire (Conners, 1973)

This is a 93 - item checklist of symptoms most commonly associated with behaviour disorders in childhood. Symptoms are rated on a four-point scale of severity. Scores may be computed for loading in one or more of eight groups: conduct problem, anxiety, impulsive-hyperactive, learning problem, psychosomatic, perfectionism, antisocial and muscular tension. A useful brief symptom questionnaire has also been developed by Conners.

3.1.1.5 Cautions in interviewing parents

As the literature presented in Chapter Two has indicated, parental responses to enquiry about their injured child may not be accurate: the parent may minimise or deny the existence of problems as a psychological defence mechanism against the distress caused by the actual effect of brain damage to the child's functioning. (Romano, 1974).

3.1.2 Teachers

Graham and Rutter (1968) point out that mothers frequently do not know about certain areas of behaviour disturbance in their children and are unlikely to have detailed knowledge about the ways in which their children behave in school. The teacher is clearly able to provide more accurate and detailed information about the child's scholastic performance, and frequently peer relationships, than is the mother. Furthermore, the teacher may provide a useful 'control' where it is suspected that a parent or relative is not accurate in reporting post-traumatic symptoms. Since the psychologist is interested in functional change, it may be necessary to obtain reports from teachers of the child pre- and post-injury.

Apart from obtaining specific scholastic and behavioural data from the teacher in her report, the following rating scales specifically developed for use by teachers may be useful. They were developed by Rutter (1967 and 1972) and Connors (1969).

3.1.2.1 Child Scale B(2) (Teachers) (Rutter, 1967)

Twenty-six statements, rated on one of a three-point scale of severity by the teacher, make up the scale. A final score of nine or more infers that disorder is present in the child.

3.1.2.2 Teacher Questionnaire (Conners, 1969)

This is a thirty-nine item symptom checklist and scholastic data report format, items divided into three groups: classroom behaviour, group participation and attitude towards authority. Scores for given items, factor-analysed into diagnostic groups, may be summed and the weighting of scores noted in one or more groups: conduct problem inattentive-passive, tension-anxiety and hyperactivity.

3.1.3 The Child

Useful information may be gathered from a pre-test interview with the child, e.g. how he experiences his family relationships, his scholastic performance, relationships with peers and whether or not he is aware of changes in himself. It may also be useful to ascertain what plans the child may have made prior to the accident for future education and occupation. How much weight is ascribed to this will depend on how commensurate previous plans appear to have been with an estimation of the child's pre-morbid ability.

3.2 Neuropsychological Assessment

3.2.1 The Test Battery

The issue here is focused on what constitutes an adequate test battery in a neuropsychological assessment following closed head injury, given that (in the situation of head injury) it is the task of the psychologist to document areas of intact and deficient functioning for purposes which are primarily descriptive, aiding in an understanding of the ways in which trauma has affected the functioning of the patient (Walsh, 1978).

3.2.1.1 The Issue of Single Tests

Use of the single test, for example the Bender Visual-Motor Gestalt Test, deficient performance on which labels the patient 'brain-damaged', has been criticised on a number of grounds. Firstly, use of a single test for organicity implies that damage to the brain matter is always expressed in one particular way or that brain damage is a unitary entity. Neuropsychological research has increasingly shown that this is a flawed assumption: damage to the brain is expressed behaviourally in various ways, depending on which functional systems have been affected by the damaged or destroyed tissue, (Lezak, 1983; Walsh, 1978; Goodglass and Kaplan, 1979). It follows then, that the brain may be damaged in an area which is not responsible for the function measured by the single test, which may then erroneously classify the patient's mental functions as intact. Secondly, and in view of the above argument, not surprisingly, single tests have high misclassification rates (Spreen and Benton, 1965).

Prominent authors in the field therefore reject the use of the single test (Lezak, 1983; Walsh, 1978; Smith, 1975) except as a cautiously interpreted screening device in a context in which organically based disorders occur more frequently than in the general population, e.g. in a general psychiatric ward (Lacks, 1982). In Lezak's words -

> ' ... Current thinking in neuropsychology recognises brain damage as a measurable multi-dimensional phenomenon that requires a multi-dimensional approach.' (p 17).

In support of the multidimensional approach with specific reference to head injury, it may be argued that neuropsychological assessment following closed head trauma does not require a screening device: a severe blow to the head followed by loss of consciousness and post-traumatic amnesia is sufficient information to indicate that brain matter has been compromised. The function of the assessment is to evaluate to what extent functions have been damaged, i.e. to what extent brain matter has been compromised. Further, significant support for the multidimensional approach is to be found in research data: for example, in studies of head injured children Levin and Eisenberg (1979a and b) and Levin, et al, (1982) noted deficits in each of the areas of language, memory, visuo-spatial, visuo-motor, somatosensory and motor proficiency functions.

3.2.1.2 Areas Assessed in a Comprehensive Battery

Swiercinsky (1979, cited in Obrzut and Hynd, 1981) carried out a factor analysis on thirty-six neuropsychological test variables and found eight groupings, each representative of a functional area: (1) a combination of receptive and expressive language skills; (2) tests requiring spatial relationships and object manipulation; (3) rapid motor coordination; (4) bilateral tactile acuity; (5) bilateral gross motor speed; and (6) right/left grip strength. In a widely recognised text on neuropsychological assessment, Lezak (1983) discussed the following major functions: general intelligence and academic achievement, verbal, perceptual, constructional, memory, conceptual and executive, motor performance, orientation and attention. In a paper specifically focussed on the factors assessed in a test battery for children, Zagar and Arbit (1980) defined the following areas: general intelligence, academic achievement, auditory and visual learning, auditory discrimination, motoric problem-solving and short-term memory.

3.2.1.3 Rationale for Test Selection

In summary, a rationale for the selection of neuropsychological tests and the formation of a test battery may be given thus -

(1) the battery must be comprehensive, including tests of differing functions (e.g. memory, motor) and within the functional areas, tests focussing on the major modalities (i.e. auditory, visual/verbal, non-verbal);

(2) tests should be selected that 'permit differentiation of the sensory and motor modalities involved in perception and execution of the task (or lower level cerebral functions) from mental or cognitive processes (higher level cerebral functions)' (Smith, 1975). Lezak (1983) points out that the most neuropsychologically meaningful tests are those which are the most pure measures of a specific function; however, many available tests are dependent on a number of processes and the specific area of deficient performance needs to be located.

In the following section, a selected list of tests suitable for children has been drawn up, the tests grouped within functional groups and divided into those testing the differing modalities of function.

3.2.1.4 Suitable Tests for Children

The following tests have been grouped together according to the functions they measure. The breakdown of functional areas has been derived from that used by Lezak (1983). References noted after the tests include those giving detailed descriptions of the tests and tables of norms. This list does not purport to be comprehensive, but it does include some of the more widely used tests in the literature.

Overall Intelligence

- Junior South African Individual Scale (JSAIS) (Madge, 1981)
- Senior South African Individual Scale (SSAIS) (Madge, 1964)
- Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974)
- Stanford-Binet L-M (Terman and Merrill, 1973)

Verbal Functions

Screening

- Aphasia Screening Test (Reitan and Davison, 1974; Selz, 1977; Knights and Norwood, 1979).

. Neurosensory Centre Comprehensive Examination for Aphasia (Spreen and Benton, 1969).

Comprehension

. Token Test for Children (Di Simondi, 1978).

. Stanford-Binet Pictorial Identification (Terman and Merrill, 1973).

Repetition

. Detroit Auditory Attention Span for Related Syllables (Baker and Leland, 1967).

. WPPSI: Sentence Repetition. (Wechsler, 1967).

. Stanford-Binet: Sentence Repetition. (Terman and Merrill, 1973).

. Detroit Auditory Attention Span for Unrelated Words (Baker and Leland, 1967).

. WISC-R: Digit Span (Wechsler, 1974; Digits Forward: Taylor, 1959).

. Sentence Repetition Test (Spreen and Benton, 1963; Spreen and Gaddes, 1969).

Production

. Renfrew Word Finding Vocabulary Scale (Renfrew 1968).

- Verbal Fluency Tests (UCT Child Guidance Clinic, unpublished norms; Borokowski, Benton and Spreen, 1967).

Sound Blending

- Sound Blending Test (Knights and Norwood, 1979).

Perceptual Functions

Visual

Visual Inattention

- Copying Names and Addresses (Lezak, 1983).

- Benton Visual Retention Test (Benton, 1964).

Colour Perception (Occipital)

- Token Test for Children: Part 1 (Di Simondi, 1978).

Visual Recognition

- Facial Recognition Test (Benton and van Allen, 1968; Levin, et al, 1975).

Visual Organisation

- WISC-R: Object Assembly subtest (Wechsler, 1974).

Visual Interference

- Visual Closure: ITPA (McCarthy and Olson, 1964).

- Embedded Figures Test (Benton-Spreen, in Spreen and Gaddes, 1969).

Auditory

Verbal

- Boston Speech Test (Knights and Norwood, 1979).
- Speech Sounds Perception Test (Reitan and Davison, 1974, Spreen and Gaddes, 1969).
- Flowers-Costello Test of Central Auditory Abilities (Flowers, Costello and Small, 1970).
- Wepman Auditory Discrimination Test (Wepman and Jones, 1961).

Non-verbal

- Seashore Rhythm Test (Reitan and Davison, 1974; Spreen and Gaddes, 1969).

Tactile-Kinesthetic

- Tactual/Tactile Performance Test (Knights and Norwood, 1979; Reitan and Davison, 1974; Spreen and Gaddes, 1969).
- Finger Recognition (Knights and Norwood, 1979; Benton, 1959, 1979; Benton, et al, 1983).
- Finger-tip Number Writing (Knights and Norwood, 1979).

. Tactile Form Recognition (Knights and Norwood, 1979).

. Stereognosis Test (Benton, in Spreen and Gaddes, 1969).

<u>Visuographic Functions</u>

. Bender Visual-Motor Gestalt Test (Bender, 1938, Hutt, 1977; Taylor, 1959).

. Benton Visual Retention Test (Benton, 1974; Taylor 1959).

. Beery Developmental Test of Visual-Motor Integration (Beery, 1982).

. Frostig Developmental Test of Visual Perception (Frostig, Marlow, Lefever and Whittlesey, 1963).

. Rey-Oosterreith Figure (Taylor, 1959).

<u>Constructional Functions</u>

. WISC-R/SSAIS Block Design subtest (Wechsler, 1974, Madge, 1964).

. WISC-R Object Assembly subtest (Wechsler, 1974).

. Kohs' Blocks (Kohs, 1923, Wechsler, 1944 in Taylor, 1959).

. Cube Construction (Taylor, 1959).

. Goldstein-Scheerer Stick Test (Taylor, 1959).

. Three dimensional constructional praxis (Benton and Fogel, 1962; Spreen and Gaddes, 1969).

Motor Functions

Motor Speed and Precision

. Detroit Motor Speed and Precision Test (Baker and Leland, 1967).

Manual Dexterity

. Finger-Tapping Tests (Denckla, 1973, 1974; Spreen and Gaddes, 1969).

. Purdue Pegboard Test (Purdue Research Foundation, 1975; Costa, Scarola and Rapin, 1964).

. Pegboard Test (Knights and Norwood, 1979).

Memory Functions

Verbal

. Auditory Verbal Learning Test (Taylor, 1959).

. Selective Reminding Test (Buschke and Fuld, 1974).

. Digits Forward (WISC-R) (Wechsler, 1974; Taylor, 1959).

. Stanford-Binet: Story and Paragraph Recall (Terman and Merrill, 1973).

Non-verbal

. Benton Visual Retention Test (Benton, 1964, Taylor, 1959).

. Rey-Osterreith Figure (Taylor, 1959).

- Non-verbal Sequential Memory (ITPA) (McCarthy and Olson, 1964).
- Stanford-Binet: Memory-for-Designs (Terman and Merrill, 1973).
- Memory for Designs Test (Graham and Kendall, 1960).
- Dynamic Visual Retention Test (Spreen and Gaddes, 1969).

Conceptual Functions

Concept Formation

- WISC-R/SSAIS Similarities subtest (Wechsler, 1974; Madge, 1964).
- SSAIS: Picture Absurdities subtest.(Madge, 1964).
- WISC-R/SSAIS: Comprehension subtests (Wechsler, 1974; Madge, 1964).
- SSAIS: Pattern Completion subtest.(Madge, 1964).
- Stanford-Binet: Similarities, Differences, Abstract Words, Opposite Analogies (Terman and Merrill, 1973).
- Category Test (Reed, Reitan and Kløve, 1965, Reitan and Davison, 1974; Spreen and Gaddes, 1969).

Ordering, Organising, Planning

- WISC-R: Mazes subtest (Wechsler, 1974).

- Trail Making Test (Reitan and Davison, 1974;
- Spreen and Gaddes, 1969).

- Colour Form Test (Reitan and Davison, 1974).

- Rey-Osterreith Figure (Taylor, 1959).

Reasoning

- Stanford-Binet: Problem Situations subtests (Terman and Merrill, 1973).

- Stanford-Binet: Verbal Absurdities (Terman and Merrill, 1973).

- Stanford-Binet: Picture Absurdities (Terman and Merrill, 1973).

- WISC-R: Picture Completion subtest (Wechsler, 1974).

- WISC-R: Picture Arrangement subtest (Wechsler, 1974).

Attention, Concentration, Tracking and Scanning

Verbal

- WISC-R; Digit Span (Wechsler, 1974).

- Subtracting Serial Sevens (Lezak, 1983).

- Paced Auditory Serial Addition Task (Gronwall and Wrightson, 1974; Gronwall, 1977).

Non-verbal

- Digit Symbol Modalities Test (Smith, 1973).
- WISC-R: Coding subtest (Wechsler, 1974).
- Continuous Performance Test (Rosvold, Mirsky, Sarson, Bransome and Lloyd, 1956).

Batteries

- Halstead Neuropsychological Test Battery for Children 9 - 14 years (Reitan and Davison, 1974; Selz, 1977).
- Reitan-Indiana Neuropsychological Test Battery for Children 5 - 8 years (Reitan and Davison, 1974; Selz, 1977).
- Luna - Nebraska Children's Battery (Golden, 1980; Golden, in Obrzut and Hynd, 1981).

Scholastic Tests

- Neale Analysis of Reading Ability (Neale, 1958).
- Graded Reading (UCT Child Guidance Clinic, unpublished norms).
- Graded Arithmetic Problems (UCT Child Guidance Clinic, unpublished norms).

- Graded Spelling (UCT Child Guidance Clinic, unpublished norms).

- Graded Dictation (UCT Child Guidance Clinic, unpublished norms).

Lateral Dominance

- Lateral Dominance Examination (Spreen and Gaddes, 1969).

3.2.2 Interpretation of Test Data

3.2.2.1 Level of Performance

Where brain damage following head injury is suspected, the aim of the assessment is to evaluate change in functioning, i.e. whether or not aspects of the child's functioning have deteriorated significantly since the injury. This implies that the functioning of the child prior to injury is of prime importance. Therefore, when a test result is obtained, the aim is to evaluate whether or not it is significantly different from that which would have been expected had the child not been injured. Such comparison is carried out against -

(i) normative data collected from the normal population: this type of data may be used in assessing functions which should be developed to a particular level by a certain age in a normal child. Use of this data implies that, prior to the damage, the child in question was sufficiently similar to a typical child in the group from which the normative data was obtained.

(ii) individual data derived from test performances of the child himself prior to injury. It is necessary to use individual data in the case of tests of overall intelligence, because this factor is normally distributed in the population, i.e. there is no particular score which a child should obtain at any given point in his development (Lezak, 1983).

Comparison is carried out -

(1) directly, (a) where it is appropriate to use normative data and (b) where scores have been obtained by a child prior to injury.

(2) indirectly, where normative data is not appropriate and specific scores obtained prior to injury are not available. In this situation the level of ability operative prior to the injury must be indirectly estimated.

Indirect Estimation of Pre-morbid ability

Lezak (1983) points out that estimates of pre-injury ability may be drawn from historical and observational data, e.g. the higher the child's previous performance at school, compared with the performance of his classmates, the more sophisticated his interests and hobbies, the higher the intellectual level within the family (assessed by parents' and siblings' scholastic achievements and occupational status), the higher the child's pre-morbid ability is likely to have been. However, Lezak notes that estimates based purely on such data may not be entirely accurate: performance at school may have been compromised by a number of factors, e.g. emotional issues, the child may not have had access to possible interests and hobbies in a culturally deprived situation and familial scholastic achievement and occupational status may not necessarily reflect familial ability, e.g. in a situation in which parents were forced to leave school for financial rather than scholastic reasons.

A number of methods for estimation based on current test data have been described by the literature. A group of such methods have been based on the principle that when the brain is damaged, verbal skills, especially vocabulary, are left intact, while others, e.g. memory, reasoning, motor functions, deteriorate, (McFie, 1975; Russell, 1979). However, this method is problematic where brain damage has resulted in verbal deficits (Russell, 1972b, cited in Lezak, 1983), or possibly where a child comes from a culturally deprived background in which verbal ability may not have developed to the maximum given the potential of the child.

Lezak therefore describes what is termed the 'Best Performance Method' in which the level of best performances is used as an estimate of pre-morbid ability. These may not only be test scores; they may, and should also be derived from historical data as well as observed behaviour and speech not specific to the test situation. A broad range of information should therefore be obtained to reconstruct the level of pre-morbid ability; generally speaking, a cluster of higher scores on a thorough neuro-psychological examination will be found, which, taken together with comprehensive historical data, should provide the basis for an estimation of pre-morbid ability.

3.2.2.2 Pattern of Performance

The study of the pattern of test scores obtained by the subject has been a further established means of evaluating performance in adults. Low scores for verbal tests have been accepted as characteristic of left hemisphere dysfunction and impaired visuo-spatial functioning of right hemisphere dysfunction (McFie, 1975; Reed and Reitan, 1963 and Newcombe, 1969, cited in Chadwick, et al, 1981a). However, research has indicated that the pattern is not clear-cut in children: McFie (1961), and Kershner and King (1974, cited in Chadwick, et al, 1981a) have found no such consistent pattern in children under 15 years old, although Chadwick, et al, (1981a) did note a tendency for tests of scholastic achievement to be impaired to a greater extent with left hemisphere damage. Verbal-Performance discrepancies on the Wechsler Intelligence Scale for Children have, in fact, been found by researchers after generalised rather than lateralised brain damage (Klonoff and Low, 1974) and in this light, Boll and Barth (in Filskov and Boll, 1981) caution against the use of Verbal-Performance discrepancy to predict lateralisation of hemispheric dysfunction in children.

3.2.3 Issues in the testing of the brain-damaged patient

Lezak (1983) cites the following as possible problems of the brain-damaged patient which should be taken into account by the psychologist during testing.

3.2.3.1 Sensory Deficits

Following head injury a patient may suffer from diplopia, which is imbalance of the eye muscle resulting in double vision. The problem may be slight, in which case the patient may not see double at all angles and in all parts of the visual field. However, in some cases it may be severe and affect the patient's performance in tests requiring subtle visual discrimination. It is wise to ask the patient about this, particularly where he/she is a child and may not volunteer the information spontaneously. An opthalmological or neurological report giving an indication of the severity of the diplopia should be obtained before testing proceeds.

3.2.3.2 Motor Deficits

Some patients who have lost the use of one hand may have retained the use of the non-preferred hand and this should be taken into account by the examiner. Dee and Fontenot (1969, cited in Lezak, 1983) have stated that neurologically intact subjects using the non-preferred hand in drawing tasks tend to make no more errors than with the preferred hand, although distortion errors made with the left hand are more severe than those made by the right hand. Thus the handedness of the unilaterally paralysed or weakened patient will generally not affect drawing tasks, but is, of course, likely to affect tests requiring motor speed.

3.2.3.3 Distractibility

As indicated in the previous chapter, this is frequently cited in the literature as a sequel to head injury in children,(Richardson, 1963; Brink, *et al*, 1970, Black, *et al*, 1981) and should be watched for during testing. The examination room and testing table should be as free of unnecessary items as possible, the examiner should avoid brightly patterned clothing and the area should be quiet.

3.2.3.4 Fatigue

The literature has pointed out that head injured children often fatigue more rapidly than normal children (Richardson, 1963; Naughton, 1971). This factor should also be watched for during testing. Telling signs are yawning, restlessness, motor slowing and slurred speech. A child may frequently reply that he is not tired when asked: this should be accepted cautiously by the examiner as a child may often give the answer he feels the examiner wants to hear. Breaking up the test battery into two or three sessions is advisable and a break during the sessions is essential for optimal performance.

3.2.3.5 Motivational Defects

In come cases, brain-damaged subjects are unmotivated. This may severely affect test performance and the child must be encouraged and stimulated to perform as optimally as possible.

3.2.3.6 Depression and Frustration

Depression and frustration are frequently closely related to fatigue in brain-damaged patients. Rapid fatigue leads to rapidly impaired performance of which the patient is often not unaware. Attempts to concentrate harder and succeed serve to drain energy still further, increasing fatigue, failure and frustration. A patient is frequently aware that he is struggling to perform a task accomplished with ease in the past and this contributes to a significant sense of loss and depression. Older children are likely to be more aware of such loss than younger patients, and children generally are likely to suffer from rapid fatigue, both as a result of their age and injury. Depression and frustration may be coped with by the psychologist who is encouraging and understanding. The child should not be allowed to fail more frequently than is necessary and should be given opportunities to succeed. Where it is realistic, the examiner may well be able to reassure the child that certain abilities will return to functioning given time. Where the child is significantly depressed and it is the examiner's impression that he is not functioning at full potential, results should be interpreted cautiously.

4 Summary

The psychological assessment of a child after he has sustained a closed head injury is aimed at the evaluation of the extent of post-traumatic change in intellectual, scholastic, neuropsychological, behavioural, emotional and social functioning. The child's parents, siblings, close relatives and teachers, as well as the child himself, are all valuable sources of information relevant to the above areas, which information is gathered by means of systematic interviewing and neuropsychological assessment using specialised tests of cognitive function. A full interview should gather information related to the psychosocial background from which the child comes and specific details personal to the child pre- and post-injury. It is argued that the need to establish whether or not change has occurred following injury as a given aetiological event justifies the development of clear, comprehensive interview schedules for follow-up of head injury cases. The neuropsychological assessment should also be comprehensive, describing the child's level of performance in a range of areas of neuropsychological function, including overall intellectual ability and language, motor, spatial and memory functions. Since the aim of the assessment is to evaluate the presence and extent of post-traumatic change and deficit, the child's level of performance is compared both with accurate normative data drawn from the normal population of equivalent age group and individual data gained from assessment of the child prior to the injury. Such detailed individual data is frequently unavailable and must be estimated as accurately as possible from the child's best performance on a wide range of historical and observational data. While reasonably clear and useful patterns of test performance have been found in adults, no consistent patterns have been found in children with lateralised brain injury and researchers have cautioned against the use of Verbal-Performance discrepancies to predict lateralisation of dysfunction in children.

CHAPTER FOUR

RESEARCH AIMS, METHODOLOGY, RESULTS, DISCUSSION AND CONCLUSIONS

1 Aims in the Context of Research to Date

As Levin and Eisenberg (1979a and b) pointed out, relatively few studies of detailed neuropsychological sequelae following closed head injury in childhood had appeared in the literature by 1979. Many studies published before that date which commented on cognitive outcome had focussed on the effect of closed head injury on full scale IQ scores (Hjern and Nylander, 1962; Richardson 1963; Brink, et al, 1970; Flach and Malmros, 1972). In general, these researchers have agreed that global intellectual ability may be impaired subsequent to injury, scores for performance IQ often being most severely lowered. In terms of specific functions impaired in the long-term following injury, Dillon and Leopold (1961) recorded gnostic, language and memory impairments and Dencker and Löfving (1958) noted difficulties with abstract thinking, figure-ground discrimination, speed, distribution of attention and manual coordination. While detailed investigation of neuropsychological functioning has been carried out in recent years by Levin and Eisenberg (1979a and b), Levin, et al, (1982) and Chadwick, et al, (1981), these studies have focussed on outcome within two years and six months after injury, and Klonoff, Low and Clark (1977) have noted that recovery continues to take place between four and five years after injury. Although Klonoff, et al, (1977) examined their subjects neuropsychologically at five years post-injury, their paper does not comment on specific residual deficits.

In this context, there would appear to be some need to follow up subjects who have sustained closed head injury in childhood with a view to some specific detailing of long-term residual deficits. The research reported in these chapters was carried out to provide some preliminary data in an attempt to fulfil this need given subjects in the South African context, with a view to informing future research in the field.

2 Method

2.1 Design

The design was structured for a retrospective follow-up study. Noting the findings of Chadwick, et al, (1981) that no subjects have even transient defects where severity of injury is mild or moderate (as defined by post-traumatic amnesia of less than twenty-four hours), this study focussed on subjects who had a history of severe to very severe head injury. It was designed to compare the performance of subjects who had sustained a severe head injury during childhood with that of normal control subjects on measures of neuropsychological functioning and to note reported changes in the physical, behavioural and scholastic functioning of the head injured subject post-injury.

2.1.1 Inclusion Criteria

Criteria for the inclusion of a subject in the head-injured group were as follows -

a. Age at injury: a subject was required to have been under the age of fifteen years at injury.

b. <u>Type of injury:</u> a subject was required to have sustained a closed head injury resulting in immediate loss of consciousness denoting diffuse, bilateral damage to the brain matter (Jennett, 1972).

c. <u>Severity of injury</u>: a subject was included if the duration of post-traumatic amnesia exceeded twenty-four hours.

d. <u>Length of time post-injury</u>: a subject was included if the head injury had occurred at least three years prior to the assessment.

e. <u>Race and language</u>: a subject was required to be Coloured, either English or Afrikaans-speaking, but proficient in one or other language.

2.1.2 Exclusion Criteria

A subject was excluded from the study on the grounds of mental retardation prior to the injury.

Inclusion of head-injured subjects on the criteria above was based on information given in hospital folders. Age, the time elapsed since injury and social class were verified by an interview with a primary caretaker (parent, foster parent, hostel nursing sister). Neurological data forming the basis for inclusion on the grounds of type and severity of injury was discussed with an experienced, qualified nursing sister. Duration of post-traumatic amnesia was established or verified by the duration of loss of consciousness. Jennett, <u>et al</u>, (1977) have indicated that loss of consciousness lasting at least six hours results in post-traumatic amnesia of over seven days. Social class of the subject was rated according to the following table -

1. professionals, business managers, executives, directors
2. employees, administrative, clerical and technical workers
3. skilled manual and semi-skilled
4. unskilled/labourer
5. pensioner
6. unemployed - no income

A letter requesting the patient to participate in the follow-up study was sent to every individual with a history of severe or very severe closed head injury in hospital records from 1966 to 1981, for whom a full address was available. Computer records indicated that 191 children sustained severe and very severe closed head injury during this period. Eighty letters were sent to recorded full addresses and twenty-seven replies were received. It is not known whether the fifty-three cases who did not reply did not do so because they had moved or chose not to do so for unknown reasons.

2.1.3 Control Group Inclusion Criteria

Criteria for inclusion of a subject in the control group were as follows -

a. Intellectual functioning: the subject was excluded if found to be mentally retarded.

b. History: a subject was excluded if there was a history of head injury or severe illness.

c. Race and Language: the subject was required to be Coloured and either English or Afrikaans-speaking.

2.2 Subjects

2.2.1 Head Injured Group

Nineteen subjects (19: 13 males and 6 females) with a history of severe closed head injury, who replied to the letter sent to them, were included in this group. The mean age of the head-injured group at injury was 6,9 years and the mean length of time which had elapsed since injury was 6,1 years (median: 5 years; range: 3 - 15 years). The mean age of this group at assessment was 12,8 years (range: 7 years and 9 months to 25 years and 3 months). All were drawn from the Coloured race group in the greater Cape Town area and were of median social class score 3 and median psychosocial adversity score 2 (see p ~~8~~ 103). All injuries were incurred in motor vehicle accidents: 14 were pedestrians hit by a moving vehicle and 5 were passengers in a vehicle involved in an accident.

The breakdown of severity in the group occured thus: 5 subjects were judged to have been in post-traumatic amnesia for from 1 - 7 days.

7 subjects were judged to have been in post-traumatic amnesia for from 8 - 20 days.

7 subjects were judged to have been in post-traumatic amnesia for 21 days and more.

2.2.2 Control Group

Ten (10: 6 males and 4 females) subjects made up the control group. They were of mean age; 9,8 years (range: 6 years and 6 months to 12 years and 5 months) and of median social class score 3.5 with a median psychosocial adversity score 3. All were drawn from the Coloured race group in the greater Cape Town area. Two control subjects were siblings of head-injured subjects and the remaining eight were orthopaedic injury patients, assessed while hospital in-patients.

2.3 Apparatus

2.3.1 Test Battery

The following criteria were used in the choice test included in the battery -

1. the test should be a measure of a function shown in other studies to be sensitive to brain injury following head trauma (see Chapter Two).

2. the test should be applicable to a wide age range (i.e. the norms were required to have low 'floors' as some subjects were expected to perform at low level).

3. the measure was required to be portable.

4. internationally-used measures were favoured to facilitate comparison of results with those of other studies.

5. the measure was required to be as free of cultural bias as possible.

2.3.2 Tests Included (the reference from which norms have been used in this study are underlined).

2.3.2.1 General Intellectual Ability

The Wechsler Intelligence Scale for Children - Revised (WISC-R) (Wechsler, 1974) was used for assessing the general intellectual ability of subjects aged six to sixteen years and the Wechsler Adult Intelligence Scale (WAIS) was used in the assessment of two subjects aged over seventeen years. The WISC-R and WAIS have been widely used in the literature (e.g. Chadwick, et al, 1981a; Levin, et al, 1982; Mandleberg and Brook 1975). Chadwick, et al, (1981c) conclude from their research that the WISC-R is particularly sensitive to the effects of generalised brain damage.

Eight subtests were used: Information, Comprehension, Arithmetic and Digit Span from the Verbal scale and Picture Completion, Block Design, Coding and Mazes from the Performance scale. Vocabulary was excluded because of difficulties in ensuring that an Afrikaans version would be equivalent to an English one. Scores were prorated to give full scale, verbal and non-verbal IQ results. Object Assembly was excluded as well to make the results of this study comparable to those of a prospective study in progress in the Department of Neurosurgery U.C.T. Medical School where Object Assembly was excluded as not being suitable for repeat testing. However, Object Assembly was included in the two cases in which the WAIS was used.

2.3.2.2 Motor

Purdue Pegboard Test (Purdue Research Foundation,1948; Costa, Scarola and Rapin, 1964).

This test requires that the subject place pegs in a pegboard with his preferred hand, then his non-preferred hand, and finally with both hands, each trial lasting for thirty seconds. A test of manual dexterity, it has been found to be sensitive to brain damage, correctly determining the presence of dysfunction in 90% of eighty patients in a neurology ward of a general hospital. The rationale underlying the test is that although manual functions may appear grossly normal, the laterality or bilaterality of damaged brain matter results in impairment of performance in the contralateral hand or both hands respectively (Smith, 1975).

Successive Finger-to-Thumb Tapping (Denckla, 1973, 1974)

The time taken to perform twenty successive finger taps by each hand was measured.

Detroit Motor Speed and Precision Test (Baker and Leland, 1967)

The subject was required to place crosses in circles of diminishing size as quickly as he could within a time limit of two minutes. Raw score was taken as the number of circles filled correctly, i.e. the cross was not permitted to fall outside the circle.

2.3.2.3 Visuographic/Visuo-spatial

Beery Developmental Test of Visual-Motor Integration (Beery, 1982)

The subject was given a series of pages with three designs on each and was required to copy each design as perfectly as he could using a pencil. Raw score was given by the number of designs copied with adequate accuracy.

2.3.2.4 Language

2.3.2.4.1 Production

Word Fluency (Borokowski, Benton and Spreen, 1967)

UCT Child Guidance Clinic, unpublished norms

The subject was asked to give as many different words as possible in one minute. Raw score was taken as the number of words given.

Renfrew Word-Finding Vocabulary Scale (Renfrew, 1968, Oldfield and Wingfield, 1964, 1965)

A series of fifty-two pictures of different objects and animals was presented to the subject, whose score was determined by the number of pictures which he could name correctly. Speed of response was measured by the mean time taken to name the object in the first ten pictures.

2.3.2.4.2 Comprehension

Stanford-Binet Pictorial Identification (Terman and Merrill, 1973) = (At four and a half year level)

A set of drawings was presented to the subject on a single card and a series of six questions asked, requiring him to point out the guide picture which provided the answer to each question, e.g. "Which one do we carry when it is raining?"; "Which one has the longest ears?"

Token Test for Children (Parts I, III and V: Di Simondi, 1978)

The subject was required to touch or move coloured circles and squares in response to an oral command. Raw score was given by the number of correct responses made by the child.

2.3.2.4.3 Repetition

Digit Repetition (Taylor, 1959)

The number of digits forward repeated correctly by the subject on the Digit Span subtest of the WISC-R and WAIS was taken as the score for digit repetition.

Detroit Auditory Attention Span for Related Syllables (Baker and Leland, 1967)

A series of sentences of increasing length was presented to the subject who was asked to repeat each directly after it was presented.

2.3.2.5 Memory

Selective Reminding Test (Buschke and Fuld, 1974)

This method of evaluating memory functions required the subject to recall as many items as he could over eight trials from a 12-item shopping list presented orally by the examiner. The full list was presented prior to the first trial and thereafter the examiner reminded the subject only of items which he failed to recall on the immediately preceding trial. The selective reminding method allows for evaluation of different aspects of memory functioning: recall the number of items recalled in each trial), long-term storage (the number of items recalled without reminder on at least one occasion) and list learning (the number of items recalled consistently with no further reminder on each trial).

2.3.3 Interview

The interview was conducted with a primary caretaker, i.e. the person most closely involved with the care of the child on a day-to-day basis. The interview format is given in Appendix A. It covered three major areas: firstly, data specific to the patient, including developmental history, health (with specific detail required on physical and mental symptoms), behaviour, education, friends and nutrition. Where applicable, areas were carefully explored for changes following head injury. Secondly, details relevant to the composition of the family were noted, including occupations of the parents and scholastic achievements of siblings. Thirdly, the social circumstances of the family were explored, including details with regard to housing and overcrowding, family history of physical and psychiatric illness and the presence of social problems in the form of alcoholism, drug abuse, crime, anti-social behaviour and child neglect and abuse. Each subject was also given a score reflecting the degree of psychosocial adversity, given by an affirmative for one or more of the following -

1. Large family size (four or more children).
2. Overcrowding (sibling-room ratio of 3:1, sibling-bed ratio of 2:1, poor housing, squatting, shared housing).
3. Breadwinner unemployed, unskilled, employment unstable.
4. Mother has academic qualification of less than Standard 6.
5. Psychiatric problem in mother, including alcoholism.
6. Psychiatric problem in father, including alcoholism.
7. Broken home, single parent, not with biological or adoptive parents.
8. Current disharmony in the home.
9. Ill-health in either parent.
10. Poor nutrition.

2.4 Procedure

The head-injured subjects were always tested in a quiet office. Testing was broken into two sessions with a short break in between. Frequently, the child's caretaker was simultaneously interviewed by a social worker or nursing sister. Where these personnel were not available, the interview was carried out by the psychologist making the neuropsychological assessment. The orthopaedic control subjects were tested at their bedside in a general ward. Every effort was made to limit noise and distractions. The two siblings of head-injured patients who acted as control subjects were assessed in an office.

The tests in the battery were always presented in the same order: visuo-spatial and motor tests, followed by the WISC-R or WAIS and finally the language and memory tests.

2.4.1 Scoring

2.4.1.1 Full Scale, Verbal, Performance IQ and Subtest Scores

The WISC-R and WAIS subtest scores were converted to scaled scores using the tables provided in the manual to correct for age. These scores were then prorated to provide full scale, verbal and performance IQ scores.

2.4.1.2 Motor, Visuographic and Language Scores

Scores for the visuo-spatial, motor and language tests were evaluated according to published norms. These scores were then corrected for age across both groups by calculating, for each subject and each score, the percentage of the subject's expected score for his age reflected by the raw score, i.e. the subject's final score for any motor, visuo-spatial or language test was his raw score expressed as a percentage of the score expected of him for that test, given his age:

$$\frac{\text{Raw Score}}{\text{Expected Score}} \times \frac{100}{1}$$

Thus if the child achieved at his expected level, his score would be 100%. If his score was below expectation for his age, it would be under 100% and if above expectation, then above 100%. Results are given in these percentage scores throughout.

2.4.1.3 Ceiling Scores

Where a subject was chronologically older than the norms for the test allowed, the score expected for his age was taken as the ceiling score on the test.

2.4.1.4 Motor Weakness

Subjects reported to be weak in either the preferred or non-preferred hand by their caretakers were excluded from the relevant conditions of the Purdue Pegboard and Finger-to-thumb tests. One subject reported weak in the preferred hand was excluded from the Detroit Motor-Speed and Precision test.

2.4.1.5 Memory

Memory scores were taken as the number of items from list recalled, the number committed to long-term storage and the number learned on each trial. At the end of eight trials, a total for each measure of memory was calculated from the sum of items recalled, committed to long-term storage or learned over eight trials.

2.4.2 Statistical Tests

The Mann-Whitney Test for non-parametic data (Siegel, 1956) was used in comparing the results of the complete head-injured sample with those of the control group on all intellectual and cognitive tests.

Fisher's exact probability test (Siegel, 1956) was used when investigating relationships between variables e.g. the relationship between increasing duration of post-traumatic amnesia and full scale IQ scores.

Although the total head-injured sample was broken into three groups according to three conditions of duration of post-traumatic amnesia, statistical analysis of differences between the groups and between the groups and the control group was not carried out due to the small number of subjects in each. Results for this breakdown of scores are discussed in terms of trends.

3 Results

3.1 Full Scale IQ

A significant difference was found between the head-injured and the control groups ($U = 30{,}5$, $SD = 21{,}7$; $p < 0{,}05$) with a mean full scale IQ score of 67,8 for the head-injured group and 87,1 for the control group.

The scores in the head-injured group were distributed as follows -

Moderate Mental Retardation : 3 (35 - 49 : DSM - 111)

Mild Mental Retardation : 7 (50 - 70 : DSM - 111)

Normal Functioning : 9 (70 + : DSM - 111)

Given histories of normal development in all subjects, ten subjects were judged to have suffered loss of global intellectual ability following head injury.

3.2 Verbal IQ

The mean verbal scores for the head-injured and control groups were 71 and 86 respectively which represents a significant difference of 15 points ($U = 39,5$, $SD = 21,7$; $p < 0,05$).

3.3 Performance IQ

The mean performance scores for the head-injured and control groups were 68 and 91, which also represents a significant difference ($U = 30,5$, $SD = 21,7$; $p < 0,05$).

TABLE 1. MEAN FULL SCALE, VERBAL AND PERFORMANCE IQ SCORES

	HEAD-INJURED SUBJECTS					
	P.T.A. 1 - 7 days	P.T.A. 8 - 20 days	P.T.A. 21 + days	TOTAL SAMPLE	CONTROL SUBJECTS	SIGNIFICANCE
N	5	7	7	19	10	
VERBAL IQ	84,2	71,3	61,9	71,2	86,1	$U=39,5$, $SD=21,7$ $p < 0,05$
PERFORMANCE IQ	83,2	72,6	54,3	68,6	90,8	$U=30,5$, $SD=21,7$ $p < 0,05$
FULL SCALE IQ	82,4	70,3	55,0	67,8	87,1	$U=30,5$, $SD=21,7$ $p < 0,05$

3.4 Severity of injury and IQ scores

A breakdown of full scale IQ scores according to duration of post-traumatic amnesia found in Table 2 (p 110) indicates that the lowest full scale scores including three in the moderately retarded range (35 - 49), occurred in the group with a P.T.A. of three weeks and over. Six of the seven scores falling in the mildly retarded range (50 - 70 : DSM - 111) were found in those subjects with a P.T.A. of more than one week.

Table 1 (p 107) reveals a steady fall-off in mean full scale, performance and verbal IQ scores as the duration of post-traumatic amnesia increases. On statistical testing, the relationships between duration of post-traumatic amnesia and full scale, performance and verbal IQ scores were found to be significant (Fisher's exact probability $<$ 0,05).

Table 3 (p 111) indicates that where P.T.A. lasted for more than one week, full scale IQ scores were found to be lower than 67 in eight cases out of 14, whereas of the five cases in which P.T.A. lasted from one to seven days, no subject tested with a full scale IQ of below 67.

Table 4 (p 111) indicates that where P.T.A. lasted for more than one week verbal IQ scores were found to be equal to or lower than 70, whereas of the five cases in which P.T.A. lasted for one week and less, only one subject scored 70 or less on the verbal scale.

Table 5 (p 111) indicates that where P.T.A. lasted for more than one week, performance IQ scores were found to be lower than 68 in 9 out of 14 cases, whereas all of the five cases in which P.T.A. lasted for less than one week achieved scores of 68 and higher.

3.5 Verbal-Performance Discrepancies

3.5.1 Head-Injured Group

Among the head injured subjects only one case presented with a discrepancy of above 30 points, a size of discrepancy which occurs in less than 1% of the normal population. Six subjects were found to have discrepancies of between 12 and 20 points, three in favour of verbal scores and three in favour of performance scores. Discrepancies of 12 points occur in approximately 12% and discrepancies of 20 points in approximately 43% of the normal population. Twelve cases were found to have verbal-performance discrepancies of less than 10 points. Discrepancies of under 10 points occur in approximately 48% of the normal population (Kaufman, 1979).

3.5.2 Control Group

In the control group, four cases were found to have discrepancies of between 12 and 20 points (found in 13% to 34% of the normal population) all in favour of performance scores. Of the remaining six cases with discrepancies below 10 points, which occur in approximately 48% of the normal population (Kaufman, 1979), one was in favour of performance and five were in favour of verbal scores.

TABLE 2. VERBAL, PERFORMANCE, FULL SCALE IQ SCORES AND VERBAL-PERFORMANCE DISCREPANCIES FOR BOTH HEAD-INJURED AND CONTROL GROUPS

HEAD-INJURED SUBJECTS

Subject	VIQ	PIQ	FSIQ	Discrepancy
	P.T.A. 1 - 7 days			
1	97	96	96	1
2	94	81	86	13
3	69	68	67	1
4	81	84	81	3
5	80	87	82	7
MEANS:	84	83	82	
	P.T.A. 8 - 20 days			
6	67	59	62	8
7	98	86	91	12
8	70	74	71	4
9	70	66	66	4
10	68	84	74	16
11	64	65	61	1
12	62	74	67	12
MEANS:	71	73	70	
	P.T.A. 21 + days			
13	50	48	44	2
14	51	65	54	14
15	70	74	71	4
16	97	52	73	45
17	70	55	60	15
18	44	41	40	3
19	51	45	43	6
MEANS:	62	54	55	
OVERALL MEANS:	71	68	67	9

CONTROL SUBJECTS

Subject	VIQ	PIQ	FSIQ	Discrepancy
1	85	78	80	7
2	79	92	84	13
3	100	93	96	7
4	79	78	76	1
5	85	84	82	1
6	75	81	76	6
7	74	93	82	19
8	106	123	115	17
9	94	106	100	12
10	84	80	80	4
MEANS:	86	91	87	8,7

TABLE 3. RELATIONSHIP BETWEEN FULL SCALE IQ AND DURATION OF P.T.A.

($p < 0,05$)

		FULL SCALE IQ < 67	FULL SCALE IQ ≥ 67	TOTALS
P.T.A.	8 + days	8	6	14
	1 - 7 days	0	5	5
TOTALS		8	11	19

TABLE 4. RELATIONSHIP BETWEEN VERBAL IQ AND DURATION OF P.T.A.

($p < 0,05$)

		VERBAL IQ ≤ 70	VERBAL IQ > 70	TOTALS
P.T.A.	8 + days	12	2	14
	1 - 7 days	1	4	5
TOTALS		13	6	19

TABLE 5. RELATIONSHIP BETWEEN PERFORMANCE IQ AND DURATION OF P.T.A.

($p < 0,05$)

		PERFORMANCE IQ < 68	PERFORMANCE IQ ≥ 68	TOTALS
P.T.A.	8 + days	9	5	14
	1 - 7 days	0	5	5
TOTALS		9	10	19

3.6 Individual Subtests

The mean scores for the individual subtests of the WISC-R and WAIS are given in Table 6 (p 113), grouped according to the severity of injury. Significant differences ($p < 0,05$) between the mean results of the whole group of head-injured subjects (the whole group was used owing to the small size of the sample) and the control group were found for Information ($U = 57$, $SD = 21,6$), Digit Span ($U = 58$, $SD = 21,6$), Block Design ($U = 37$, $SD = 21,5$), Coding ($U = 49$, $SD = 19,9$) and Mazes ($U = 28$, $SD = 17,8$). Non-significant differences in scores ($p < 0,05$) were found for Picture Completion ($U = 60$, $SD = 21,6$), Comprehension ($U = 62$, $SD = 21,6$) and Arithmetic ($U = 58,5$, $SD = 21,6$). However, it is noteworthy that where P.T.A. lasted for three weeks and longer, scores were clearly lower than those of the controls for every subtest and in every case were the lowest when compared with the scores of the other two head-injured groups. Where P.T.A. lasted from 8 to 20 days, trends indicated that Block Design and Coding scores were lowered relative to the control scores. Where P.T.A. lasted for up to one week, lowered scores relative to the performance of the control group were suggested for Block Design and Mazes.

TABLE 6. WISC- R/WAIS SUBTEST MEAN SCORES

	HEAD-INJURED SUBJECTS					
	P.T.A. 1 - 7 days	P.T.A. 8 - 20 days	P.T.A. 21 + days	TOTAL HEAD INJURY SAMPLE	CONTROL SUBJECTS	SIGNIFICANCE
N	5	7	7	19	10	
Information	6,6	5,6	3,7	5,2	7,3	p < 0,05
Comprehension	6,6	5,6	3,3	5,1	7,0	NS
Arithmetic	8,4	6,4	4,1	6,1	8,0	NS
Digit Span	8,2	5,6	4,4	5,9	7,7	p < 0,05
Picture Completion	8,6	6,9	3,3	6,1	8,5	NS
Block Design	7,2	6,9	3,1	5,6	9,5	p < 0,05
Coding	7,2	4,4	2,3	4,4	6,9	p < 0,05
Mazes	7	7,6	3,8	6,1	9,8	p < 0,05

3.7 Specific Areas of Neuropsychological Functioning

3.7.1 Motor-speed; Visuographic, and Language Functioning

Results are presented in Table 7 (p 116). Significant differences between the scores for the head-injured and control groups (p < 0,05), using the complete head-injured group, were found for -

(a) the performance of the preferred hand (U = 39,5, SD = 20,7) and both hands (U = 23,5, SD = 14,8) on the Purdue Pegboard Test;

(b) performance on the Detroit Motor Speed and Precision Test (U = 13,5, SD = 21,7);

(c) performance on the Beery Developmental Test of Visual-Motor Integration (U = 16,5, SD = 21,7);

(d) the number of words given in the Word Fluency Test ($U = 38,5$, $SD = 21,7$), and

(e) speed of response in naming objects on the Renfrew Word-Finding Vocabulary Scale ($U = 35$, $SD = 21,6$).

Non-significant differences ($p > 0,05$) were found for -

(a) the Finger-to-thumb test: preferred ($U = 69,5$, $SD = 20,8$) and non-preferred hand ($U = 43$, $SD = 16,1$);

(b) the Comprehension tests: Stanford-Binet Pictorial Identification ($U = 65$, $SD = 15,3$), Token Test for Children (Part I: $U = 49,5$, $SD = 12,3$ Part III: $U = 56$, $SD = 17,2$; Part V: $U = 52$, $SD = 17,6$);

(c) the Repetition tests: Detroit Auditory Attention Span for Related Syllables ($U = 90$, $SD = 21,7$) and Digits Forward ($U = 90,5$, $SD = 21,1$); and

(d) the Object Naming test: Renfrew Word-Finding Vocabulary Scale ($U = 95$, $SD = 21,7$).

A breakdown of mean scores according to the duration of post-traumatic amnesia revealed that where P.T.A. lasted for three weeks and more, scores were clearly lowered relative to those of the controls in every specific test except those of Verbal Repetition. In this group, speed of response in naming objects was clearly lengthened in comparison with the control speed. In comparison with the other two head-injured groups the scores for this group were the most impaired, except again for the Verbal Repetition tests.

In the group in which P.T.A. lasted from 8 to 20 days (over one week and up to three weeks), the means suggested that this group was impaired in its performance on the Preferred Hand and Both Hands conditions of the Purdue Pegboard test, on the Detroit Motor-speed and Precision test, on the Beery Developmental test of Visual-Motor Integration and in the Word Fluency test.

In the group for whom P.T.A. lasted for up to one week, study of trends suggested that the Detroit Motor-speed and Precision test and the Word Fluency test were impaired relative to the performance of the control group.

3.7.2 Cut-off Scores

As indicated earlier, scores were calculated as a percentage of the score expected for each subject's age from published norms given by the authors referenced when the tests were described. Cut-off scores (in percentages of the expected scores for the subject's ages) were determined by the lowest score found in the control group, impairment in function in the head-injured group taken as a score falling below this value. These cut-off scores are given in Table 8 (p 117), together with the number of head-injured and control subjects whose scores fell below this value. Motor weakness in the preferred or non-preferred hand reduced the number of scores taken into account in the motor tests. The tests found to discriminate between the head-injured and control groups

TABLE 7. SPECIFIC NEUROPSYCHOLOGICAL TEST MEAN SCORES

SPECIFIC COGNITIVE TESTS	P.T.A. 1 - 7 days	P.T.A. 8 - 20 days	P.T.A. 21 + days	TOTAL HEAD INJURY SAMPLE	CONTROL SUBJECTS	SIGNIFICANCE
N	5	7	7	19	10	
			Percentage Scores			
MOTOR						
Purdue Pegboard:						
Preferred Hand	93,5	83,0	62,9	79,8	99	$p < 0,05$
Non-preferred Hand	91,7	92,8	75,0	86,5	101,6	NS
Both Hands	96,0	84,5	59,5	80,0	97,7	$p < 0,05$
Finger-to-thumb:						
Preferred Hand	95,5	105,0	67,6	89,4	106,8	NS
Non-preferred Hand	105,3	100,3	54,0	86,5	107,1	NS
Detroit Motor-Speed and Precision Test	69,8	67,0	45,7	60,8	100,1	$p < 0,05$
VISUOGRAPHIC						
Beery Developmental Test of Visual-Motor Integration	90,2	71,4	53,7	71,8	99,7	$p < 0,05$
LANGUAGE						
Production						
Word Fluency	55,8	63,7	50,6	56,7	84,5	$p < 0,05$
Renfrew Word-Finding Vocabulary Scale	78,0	91,1	63,6	77,6	80	NS
COMPREHENSION						
Stanford-Binet Pictorial Identification	89,8	97,5	95,1	94,1	100	NS
Token Test 1	96,0	98,6	67,5	87,4	100	NS
Token Test 111	100	92,9	57,3	83,4	88,7	NS
Token Test V	86	77,7	32,3	65,3	80	NS
Repetition						
Detroit Auditory Attention Span for Related Syllables	94,2	65,4	68	75,9	76,1	NS
Digit Repetition	82,6	76,3	82,9	80,6	82,3	NS
			Time in Seconds			
Response Latency in naming objects	1,4	1,4	2,1	1,6	1,2	$p < 0,05$

NOTE: All scores, apart from those for response latency in naming objects are given as mean figures, calculated from the individual scores of subjects which were expressed in each case as a percentage of the expected score for the subject's age according to published normative data.

TABLE 8. CUT-OFF SCORES AND FREQUENCY OF IMPAIRMENT IN NEUROPSYCHOLOGICAL TESTS

SPECIFIC NEUROPSYCHOLOGICAL TEST	CONTROL CUT-OFF SCORE	NO. OF CONTROL SUBJECTS BENEATH CUT-OFF	NO. OF HEAD-INJURED SUBJECTS BENEATH CUT-OFF SCORE			
			P.T.A. 1 - 7 days	P.T.A. 8 - 20 days	P.T.A. 21 + days	TOTAL SAMPLE
MOTOR						
Purdue Pegboard:						
Preferred Hand	80%	0	0/4	3/7	5/7	8/18
Non-preferred Hand	80%	0	1/3	1/6	2/4	4/13
Both Hands	70%	0	0/2	1/6	3/4	4/12
Finger-to-thumb:						
Preferred Hand	70%	0	1/4	1/7	2/7	4/18
Non-Preferred Hand	80%	0	0/3	1/6	3/4	4/13
Detroit Motor-speed and Precision Test	70%	0	2/4	4/7	6/7	12/18
VISUOGRAPHIC						
Beery Developmental Test of Visual-Motor Integration	70%	0	1/5	3/7	6/7	10/19
LANGUAGE						
Production						
Word Fluency	50%	0	1/5	2/7	3/7	6/19
Renfrew Word-finding Vocabulary Scale	60%	0	0/5	0/7	4/7	4/19
Comprehension						
Stanford-Binet Pictorial Identification	100%	0	3/5	1/7	2/7	6/19
Token Test 1	100%	0	1/5	1/7	3/4	5/16
Token Test 111	80%	1	0/5	1/7	2/4	3/16
Token Test V	70%	1	0/5	2/7	4/4	6/16
Repetition						
Detroit Auditory Attention Span for Related Syllables	50%	0	0/5	1/7	2/7	3/19
Digit Repetition	60%	0	0/5	0/7	1/7	1/19
Response Latency in naming objects	1,5 secs.	0	1/5	2/7	5/7	8/19

NOTE: The cut-off score is a mean figure calculated from the individual scores of control subjects which were expressed in each case as a percentage of the expected score for the subject's age according to published normative data.

FIG 1 RECALL: Mean number of items recalled in each trial

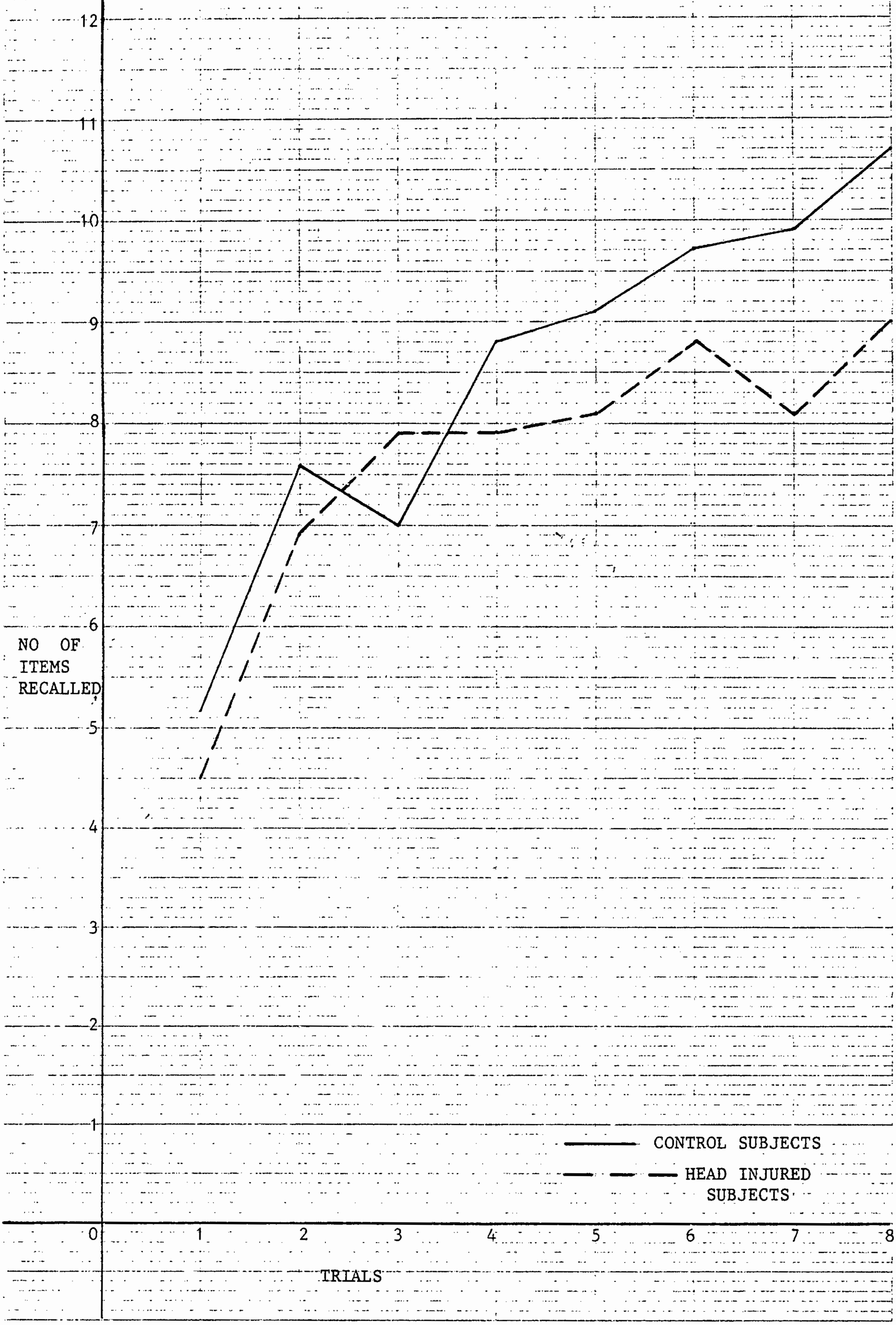


FIG 2 LONG TERM STORAGE: Mean number of items committed to long term storage in each trial

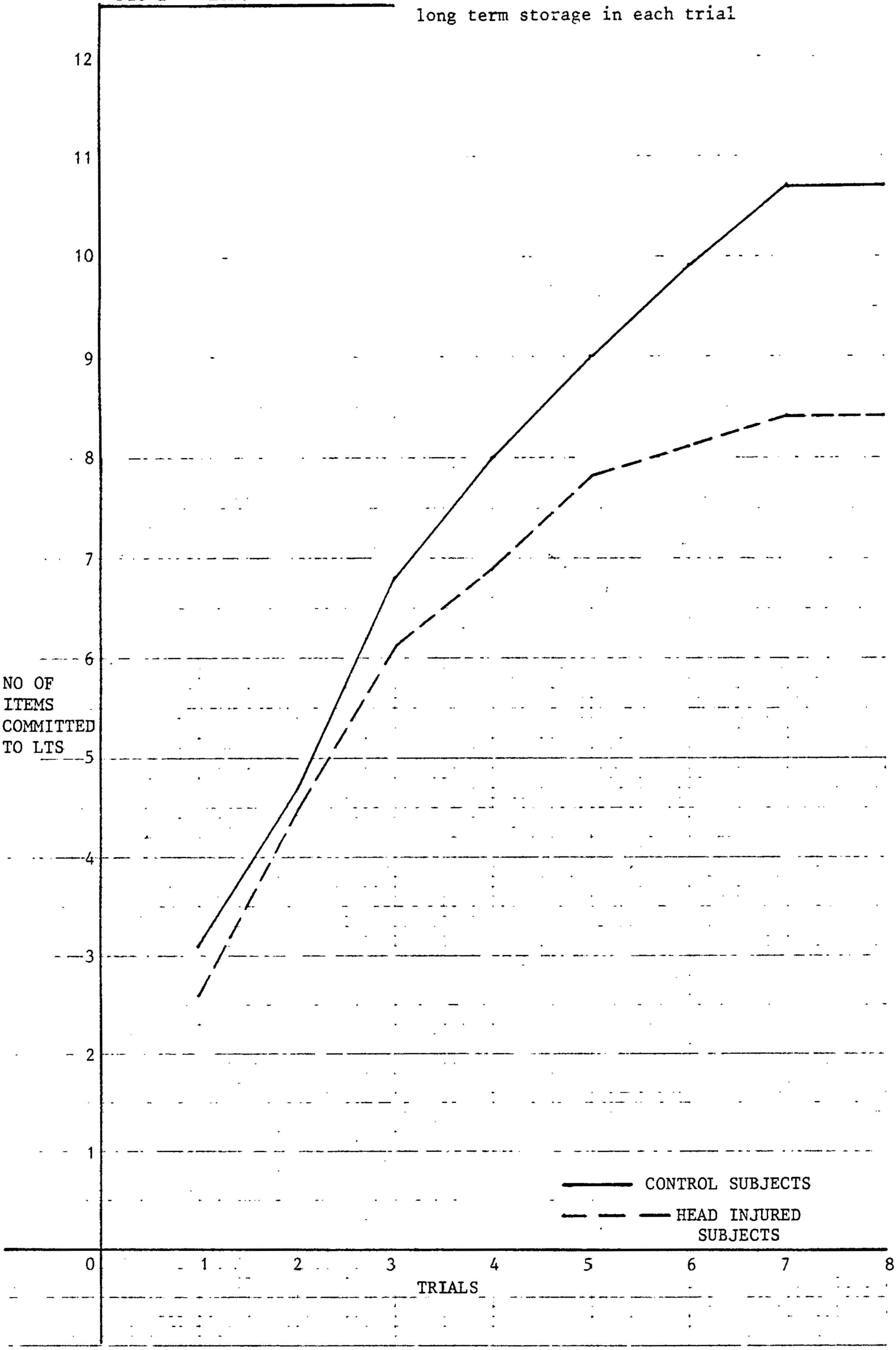
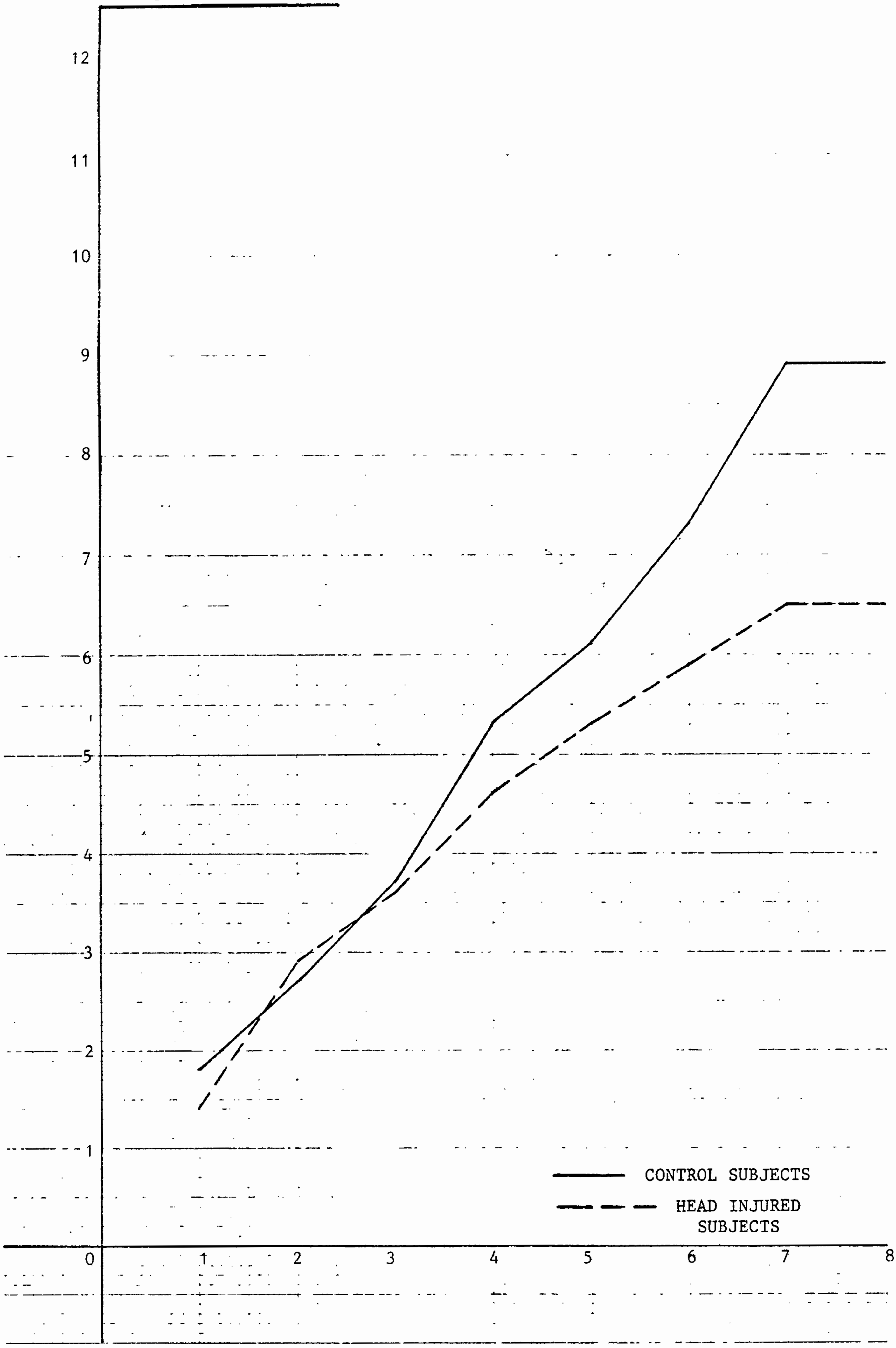


FIG 3 LIST LEARNING: Mean number of items learned in each trial



most frequently were the Detroit Motor Speed and Precision test, impaired in 12 out of the 18 head-injured subjects and the Beery Developmental Test of Visual Motor Integration, impaired in 10 out of the 19 head-injured subjects. Where P.T.A. lasted from 1 to 7 days, the only specific test impaired with apparent frequency was the Detroit Motor-speed and Precision test. Where P.T.A. lasted from 8 to 20 days (over one week and up to three weeks) tests impaired with apparent frequency were the Purdue Pegboard test, (on the preferred hand), the Detroit Motor-speed and Precision test and the Beery Developmental test of Visual-Motor Integration. Where P.T.A. lasted for three weeks and more, all conditions of the Purdue Pegboard test were judged to be frequently impaired. Frequent impairment was also apparent for the Finger-to-thumb test (non-preferred hand), the Detroit Motor-speed and Precision test, the Beery Developmental test of Visual-Motor Integration, the Word Fluency test and the Renfrew Word-Finding Vocabulary Scale, all three conditions of the Token Test and for response latency in naming objects.

3.7.3 Memory

Results were analysed for subjects under twelve years of age as an adequate control group could only be set up for this age group. Eight subjects were placed in the head-injured group (mean ages: 9,7 years) and nine in the control group (mean age: 9,4 years). Results are tabled in Table 9 (p 122), and presented graphically in Figs. 1 - 3. Although the mean total scores of the head-injured group were consistently lower than those of the control group on all measures of memory, these differences did not reach statistical significance ($p < 0,05$): i.e. for the total number of items recalled ($U = 31,5$), the total number of items learned in the list ($U = 32$). A breakdown of scores according to duration of post-traumatic amnesia for the complete sample indicates that although scores are uncontrolled for the age of subjects, the lowest scores were found on all three memory measures in the group with a post-traumatic amnesia of three weeks and longer.

TABLE 9. MEAN TOTAL FOR SUBJECTS AND CONTROLS UNDER 12 YEARS. NUMBER OF ITEMS RECALLED, COMMITTED TO LONG TERM STORAGE AND LEARNED

SUBJECT	HEAD-INJURED SUBJECTS	CONTROL SUBJECTS	SIGNIFICANCE
N	8	9	
Recall	62,4	67,9	U = 31,5, SD = 10,3 NS
Long Term Storage	52,8	62,9	U = 32,5, SD = 10,3 NS
List Learning	36	44,9	U = 32 , SD = 10,43 NS

TABLE 10. MEAN TOTAL NUMBER OF ITEMS RECALLED, COMMITTED TO LONG TERM STORAGE AND LEARNED FOR COMPLETE SAMPLE

	HEAD-INJURED SUBJECTS					
SUBJECT	P.T.A. 1 - 7 days	P.T.A. 8 - 20 days	P.T.A. 21 + days	MEANS FOR TOTAL SAMPLE	CONTROL SUBJECTS	SIGNIFICANCE
N	5	7	7	19	10	
Recall	66,6	70,1	54,6	63,8	69,1	U=85, SD=21,7; NS
Long Term Storage	55,4	64,6	48,4	56,1	65,4	U=78, SD=21,7; NS
List Learning	39,8	47,7	23,4	37,0	45,8	U=86, SD=21,7; NS

3.8 Full Scale IQ and Neuropsychological Functioning

Using a mean score (i.e. mean percentages of expected scores for the ages of the individual subjects) for neuropsychological functioning drawn from the motor, visuographic and three language tests (Word Fluency, Sentence Repetition and Object Naming), a significant relationship (Fisher's exact probability < 0,05) was found between full scale IQ and neuropsychological functioning. Six subjects out of ten who tested with full scale IQs of under 70, also achieved below a 70% average on the specific neuropsychological tests, whereas only one case out of 9 who scored above 70 on full scale IQ, scored below 70% average for the specific function tests.

TABLE 11. RELATIONSHIP BETWEEN FULL SCALE IQ AND NEUROPSYCHOLOGICAL FUNCTIONING ($p < 0,05$)

		MEAN % SCORE		TOTAL NO. OF SUBJECTS
		< 70	>70	
FULL SCALE IQ	< 70	6	4	10
	> 70	1	8	9
TOTAL NO. OF SUBJECTS		7	12	19

3.9 Physical Complaints after Injury

Results are presented in Table 12 (p 124). Headache and motor weakness were the two most frequently reported physical sequelae to head injury, occurring in nine out of seventeen cases for whom detailed information was obtained from interview with caretakers.

TABLE 12. FREQUENCY OF PHYSICAL COMPLAINTS FOLLOWING CLOSED HEAD INJURY

SYMPTOM	FREQUENCY REPORTED IN HEAD-INJURED GROUP (N = 17)
Headache	9
Motor Weakness (Unilateral)	7
Sensitivity to noise	6
Easily Fatigued	5
Impaired eyesight	5
Coordination	5
Nausea	3
Eating Problems	3
Bedwetting	3
Convulsions	2
Sensory Problems	2
Disturbances of Speech	1
Sleeping Problems	1
Blackouts	0
Dizziness	0
Hearing	0

3.10 Behavioural Changes after Injury

Results are presented in Table 13 (p 125). No subjects were found to be hyper- or under-active, but three were classed as very active subsequent to injury. Increased irritability and impatience was the most commonly disturbed self-control behaviour subsequent to injury (eight cases), followed by a low tolerance for stress (five cases). A tendency to worry and fearfulness was reported in six cases, as was a tendency to be withdrawn. Conduct problems were not frequently reported, difficulties with discipline being reported in only one case and truanting occurring in only 2 cases subsequent to injury.

TABLE 13. FREQUENCY OF BEHAVIOURAL CHANGES FOLLOWING CLOSED HEAD INJURY

BEHAVIOURAL CHANGES FOLLOWING INJURY		FREQUENCY REPORTED IN HEAD-INJURED GROUP (N = 17)
ACTIVITY :	Very Active	3
	Hyperactive	0
	Underactive	0
CONTROL :	Irritable/impatient	9
	Low Tolerance for Stress	5
	Aggressive	2
	Fussy, overparticular	2
	Careless (Dress, Hygiene)	1
	Attention-seeking	1
	Impulsive	1
	Talkative	0
	Asks Embarrassing Questions	0
ANXIETY :	Worried, Fearful	6
	Specific Fears	3
MOODS :	Withdrawn	6
	Changes easily	4
	Too cheerful	2
	Apathetic	1
	Tearful	1
CONDUCT :	Truanting	2
	Discipline Problem	1
	Stealing	0
	Lying	0

3.11 Scholastic Functioning after Injury

Results are presented in Table 14 (p 126). Scholastic failure and learning difficulties subsequent to head injury were found in eleven out of seventeen subjects. Of this group, seven scored below 70 on full scale IQ, seven had visuo-spatial deficits and six were deficient in motor speed; five were reported to have impaired ability to attend and seven were found to be forgetful subsequent to the head injury.

In the complete sample, impaired ability to attend was found in eight out of seventeen subjects and eleven subjects were reported to be forgetful subsequent to the head injury.

TABLE 14. FREQUENCY OF SCHOLASTIC DIFFICULTIES FOLLOWING CLOSED HEAD-INJURY

PROBLEM	NO. OF CASES (N = 17)
Scholastic Failure	11
Impaired attention	8
Forgetfulness	11
Learning difficulties	11

4 Discussion

Full Scale, Verbal and Performance IQ Scores

An overall significant difference between the head-injured and control groups in terms of intellectual functioning on the full scale, verbal and performance scores in favour of the controls, together with a full scale level of functioning which is below normal and representative of a loss of general ability in ten out of nineteen subjects confirm the findings of a number of previous studies: Hjern and Nylander (1962) found that nine out of twenty-two subjects with loss of consciousness exceeding twenty-four hours post-injury were intellectually retarded at follow-up and Richardson (1963) reported a ten to thirty point drop in full scale IQ in head-injured children from two to three years post-injury. Support for the finding of a global cognitive deficit in the long term following head injury has also been given in the work of Brink, et al, (1970), Black, et al, (1981) and Chadwick, et al, (1981b) Particularly in terms of the work of Chadwick, et al, (1981b),the significant relationship found in this study between increasing duration of post-traumatic amnesia and decreasing full scale, verbal and performance IQ scores is important: Chadwick, et al, found global IQ deficit in subjects whose post-traumatic amnesia had lasted for three weeks and more, less marked impairment when P.T.A. lasted from one to three weeks and concluded that serious intellectual deficit was unlikely where P.T.A. lasted from 1 to 14 days. In this study, the trends presented in Table 1 (p 107) indicate that the lowest scores were to be found consistently in the group of subjects who had histories of post-traumatic amnesia in excess of 3 weeks, each of these mean scores falling below the cut-off point for normal functioning (70: DSM - 111). Scores were not as severely impaired where P.T.A. lasted from 8 to 20 days, but it is noteworthy that the scores were 15 to 18 points below those of the controls. Where P.T.A. was found to have lasted from 1 to 7 days trends indicate very similar scores to those of the controls. Thus it would appear that the results of this study confirm those of Chadwick, et al, (1981b) permanent intellectual deficit is likely after P.T.A. of 21 days and over, some impairment is possible where P.T.A. lasts from 1 to 3 weeks and intellectual deficit is unlikely where P.T.A. lasts for less than 1 week.

It is of interest that, while the deficits for the Performance IQ scores in the two more severely injured groups seem compatible with those reported by Chadwick, et al, (1981b), the verbal IQ scores in the present sample did not reveal the degree of recovery which would have been expected from the work of Chadwick, et al. In the present sample, there was a 24 point discrepancy between the verbal IQ scores for the group with 3 weeks P.T.A. and the control group, compared with a deficit of 14 points in Chadwick's sample. In the present group with one to three weeks P.T.A. a deficit of 15 points was noted, in comparison with the complete recovery of this range of severity in Chadwick's sample. There is thus an apparent failure of expected verbal recovery in the sample used in this study.

Kaufman (1979) has noted that cultural deprivation, poor school achievement and low verbal IQ are consistently related. It should be noted that the rate of psychosocial adversity in both head-injured and control groups was high, with median scores of 2 and 3 respectively. Further, the median social class score of the head-injured sample was 3 and that of the control group 3,5. Poor school achievement was found in eleven of the head-injured subjects subsequent to injury. Thus the combination of cultural deprivation and scholastic backwardness in this sample may be hypothesized to be the root of a greater verbal deficit at follow-up than was found in groups of British children with comparable severity of head injury.

Verbal-Performance Discrepancies

The above argument continues to be of interest when attention is drawn to the pattern of discrepancy between the mean verbal and performance scores in the control group, this pattern being one of a five point difference in favour of the performance scores. While this is not a significant discrepancy, the trend is of interest and may be followed up in further studies of normal Coloured South African children. It would suggest that the Coloured child is at a pre-injury Verbal disadvantage. This becomes important when looking at Verbal-Performance score discrepancies of the individual child. At first glance in a given case it may appear, from the low discrepancy, that verbal scores are as impaired as Performance scores. However; this need not be the case: in the present study the mean Performance score dropped twenty-three points in the head-injured group, compared with a verbal drop of fifteen in the presence of a Verbal-Performance discrepancy of only three points. Thus it is possible that in an individual case of a severely head-injured Coloured child the performance score is reflective of a much greater deficit than the verbal, but that the verbal-performance discrepancy is minor due to the possibility that the verbal score was lower than the performance score pre-injury, a situation which, it is hypothesized, has its roots in cultural deprivation.

WISC-R/WAIS Subtests and Neuropsychological Functions

Given that the WISC-R and WAIS subtests are multifactorial, i.e. they have multiple determinants (Walsh, 1978) the significantly depressed scores for Block Design, Coding, Mazes and Digit Span may be reflective of a number of different dysfunctional areas. The basic material for the discussion of these areas in this section has been drawn from Kaufman (1979). Both Coding and Digit Span require sustained attention and are thus susceptible to distractibility, which is compatible with parental reports of impaired ability to attend in eight out of seventeen subjects. Naughton (1971) has also drawn attention to distractibility as a sequel to head-injury in childhood, as has Brink, et al, (1970) and Black, et al, (1971).

Adequate performance in Coding requires efficient integration of functioning and intact visual-motor coordination, areas which are also tapped by Block Design and Mazes. These subtests also assess visual perception of abstract stimuli and the ability to follow a visual pattern. Block Design is specifically a test of the ability to analyse a whole into component parts, visualize spatially and reproduce accurately. Deficit in visual-perceptual and visual-motor functions is supported by the significantly lowered performance of head-injured subjects on the Beery Developmental Test of Visual-Motor Integration and visuo-spatial deficits following head injury in children have also been reported by Levin, et al, (1979a and b).

Besides being a test of visual-motor coordination, Coding is a specific test of psychomotor speed and short-term visual memory. That scores were significantly lowered among head-injured subjects on the Detroit Motor Speed and Precision Test supports the hypothesis that impairment in psychomotor speed is at least partly the root of the impairment found in Coding.

The importance of the deficits in visuo-spatial functioning and motor-speed in these results is given by the fact that they were the two areas most frequently impaired in the sample. Findings of decreased motor-speed following head injury in childhood have also been reported by Levin, et al, (1979a and b) who found the area to be one of the most frequently impaired in their sample and Chadwick, et al, (1981b) who noted decreased speed in finger-tapping tests. While the finger-tapping test used in this study was not significantly impaired in the head-injured group, trends indicate lowered proficiency and support the significant findings in the Detroit Motor Speed and Precision Test. It bears mention that many subjects were over the ceiling age of the finger-tapping norms used, which may well have reduced subtle discrimination of impairment as a ceiling score was probably given in a number of cases in which dysfunction was present.

The significantly impaired performance of head-injured subjects on the Purdue Pegboard test supports the indications of poor speed (since this is a timed test), and more specifically illustrates poor manual dexterity following head injury, a finding again supported by Chadwick, et al, (1981b and c).

The finding in this study that Verbal Fluency is significantly impaired in the head-injured group is compatible with a report by Pendleton, et al, (1982) that verbal fluency is impaired following diffuse and frontal lesions.

Significantly lengthened response time for naming objects has been recorded by Chadwick, et al, (1981c)at one year post-injury and the finding that verbal response speed was significantly lengthened in this sample is of interest in the context of impairment in motor-speed noted earlier.

The lack of significance of the differences in performances between the two groups in the other verbal tests may be misleading: from the frequencies of impairment according to cut-off score presented in Table 8 (p 117), it would appear that comprehension and object naming are impaired where P.T.A. lasts for three weeks and more. The non-significant result where the scores of the total sample were taken into account may have been due to norms which were insufficiently extensive to pick up impairment in older subjects scoring at ceiling level but possibly having subtle verbal impairments. This area is one which may be followed up more precisely in future research. For the moment, however, it appears that where P.T.A. lasts for less than three weeks there is a recovery of basic verbal functions in the long-term, which is interesting when compared with the apparent failure of verbal IQ recovery in the group in P.T.A. from one to three weeks.

Continuing the comparison between the three head-injured groups defined by increasing duration of post-traumatic amnesia, it is found that neuropsychological trends suggest a similar result to that of Chadwick, et al, (1981b): where post-traumatic lasts for three weeks and over, a pervasive impairment of function appears to occur. The trends for the group defined by post-traumatic amnesia of over one week but less than three weeks suggest that where an injury of this severity is sustained, scores of global intellectual functioning may fall within the range of normal functioning except when the subject is faced with a task with a visual-motor component which requires motor-speed in effective performance. Indications of impaired manual dexterity and deficient word fluency are also to be found in this group and it is noteworthy that both these tests required speed for effective performance.

Of great interest is the trend for impaired motor-speed and precision in the group in which post-traumatic amnesia lasted for only one week and for whom no global impairment in intellectual functioning was apparent. It may well be such impaired speed and precision which is responsible for a possible lowering of scores for Block Design and Mazes. Indication of impairment was also found for Word Fluency in this group and it is worth noting, as above, that this test required adequate speed of word production for effective performance.

Memory

In view of the research reported by Levin, et al, (1982) the non-significant results for the memory differences between subjects and controls under twelve years are surprising. However, analysis of trends presented graphically clearly indicates that head-injured subjects fall below the controls on every aspect of memory functioning. This, together with the fact that subjects in P.T.A. for over seven days performed at a lower level than subjects in P.T.A. for under seven days, suggests that verbal memory is possibly impaired in the long-term after severe closed head injury, and that these results are possibly diluted by the effects of less severe injury. A further possible reason for the lack of significant findings may be that the test used was not sufficiently difficult to discriminate between the groups: Levin, et al, (1982) used a list of unrelated words in their study, a more difficult memory test than a shopping list. Analysis of the graphic presentations of data suggests that, over the initial four trials, the head-injured subjects scored at a similar rate to the controls, but from the 5th trial to the 8th they lost "momentum", continuing to recall, commit to storage, and consistently retrieve items, but at a slower rate than the controls, finally having lower total scores for all three areas.

Full Scale IQ and Neuropsychological Functioning

The finding that full scale IQ predicts neuropsychological functioning is in agreement with the conclusion drawn by Klonoff, et al, from their research (1977). However, as the above discussion suggests, it appears that deficits in specific areas of neuropsychological functioning may occur where full scale IQ is within normal limits, a finding supported in the literature by Chadwick, et al, (1981c).

Physical, Mental and Behavioural Complaints

Some physical, mental or behavioural sympton was noted for every subject for whom a detailed interview was obtained. The finding that headaches, a tendency to irritability and impatience, forgetfulness and decreased attention, were the most frequently reported complaints representative of change following head injury.

is consistent with other reports in the literature (Black, et al, 1971; Fuld and Fisher, 1977; Brown, et al, 1981; Richardson, 1963 and Brink, et al, 1970). It is interesting to note that hyperactivity did not appear on the list of those symptoms present with some frequency and this would tend to support the conclusion, drawn by Brown, et al, (1981), that overactivity does not seem to be especially associated with brain damage in children.

Brown, et al, (1981) have suggested that development of new psychiatric disorder occurs as a function of pre-injury behaviour characteristics together with the severity of injury and the presence of psychosocial adversity. It is of note that the incidence of psychosocial adversity in this sample was high: fifteen out of the seventeen subjects from whom detailed interviews were obtained scored on at least one aspect of the psychosocial adversity scale. The influence of this factor on post-traumatic behavioural sequelae in a population group in which psychosocial adversity appears to occur at such a high rate may well be a profitable area for further research.

Scholastic Functioning

As Fuld and Fisher (1977) have indicated, and this study confirms, scholastic difficulty and failure frequently occur subsequent to severe head injury in childhood. Possible reasons for failure are suggested by the frequency with which attentional motor speed and visuo-spatial disorders occurred in this group.

Normative Data

As was indicated in Chapter Three, an accurate assessment of suspected neuropsychological impairment in the individual child requires accurate normative data against which the child's performance on neuropsychological measures may be directly compared. Such normative data assumes that the assessed child is typical of the population from which the norms were obtained. From the test results of the control group as a sample of the normal South African Coloured population in this study it would appear that for some tests international norms cannot automatically be assumed to apply. While mean scores for the motor tests were comparable with published norms, this was not the case in the language tests, in which mean control scores were found to be from 76% to 89% of those expected.

In the context of assessment of the individual subject, this situation suggests that, against published norms, a subject may appear to be cognitively impaired when this is not in fact the case when the patient's performance is compared with normative data drawn from the population from which he comes. The need for the gathering of accurate normative data for tests of neuropsychological functions in the normal South African Coloured population is thus emphasized.

Conclusions

In summary, the results of this study indicate that, at long term follow-up after closed head injury,incurred whilst under the age of fifteen years, global intellectual deficit is to be found most frequently where the duration of post-traumatic amnesia exceeds three weeks. Results suggest that global impairment is unlikely where post-traumatic amnesia lasts for less than one week. Subjects with a history of three weeks post-traumatic amnesia were found to be pervasively impaired in specific tests of neuropsychological function i.e. they manifested a consistently lower level of functioning than the control subjects in tests of motor, visuographic, language and verbal memory functioning. Post-traumatic amnesia of over one week but less than three weeks duration appears to predispose the subject to long-term impairment in manual dexterity and motor-speed and precision as well as in visuographic functions and language production (Word Fluency). Post-traumatic amnesia of less than one week appears to result in impaired motor-speed and precision and deficient language production in terms of Word Fluency. From the results, it is suggested that it is motor-speed and precision which is the function most sensitive to the effects of closed head injury.

From the frequency with which post-injury changes were reported, the individual who receives a severe head injury as a child is likely to suffer headaches and motor weakness on one or other side of the body, become irritable and impatient, anxious, withdrawn, have a low tolerance for stress and suffer from impaired ability to attend, forgetfulness, learning difficulties and scholastic failure in the years following the injury.

The importance of these results lies in the length of time between injury and follow-up: at a mean of six years after the injury they give some indication of what may be expected in the long-term following closed head injury. However, it must be borne in mind that these results do not have status beyond that of trends and are <u>suggestive</u> of outcome patterns only in the Coloured South African who suffers closed head injury as a child. Further research is required, using far greater numbers and stringent statistical methods, carefully comparing groups formed according to duration of post-traumatic amnesia, before more definitive statements may be made.

REFERENCES

REFERENCES

Adams J.H; Mitchell D.E; Graham D.I; and Doyle D; Diffuse brain damage of immediate impact type; Brain, 1977; 100; 489 - 502

Åkerland E; The late prognosis in severe head injuries; Acta Chir. Scandinar, 1959; 117; 275 - 277

Artiola I; Fortuny L; Briggs M; Newcombe F; Ratcliff G; and Thomas C; Measuring the duration of PTA; J. Neurol, Neurosurg and Psych, 1980; 43; 377-379

Baker H; Leland B; Detroit Tests of Learning Aptitude; Examiners Handbook Revised Indiana; Bobbs; Merrill Co, 1967

Becker B; Intellectual changes after Closed Head Injury; J. Clin. Psychol, 1975; 31; 307 - 309

Becker D.P; Grossman R.G; et al Head Injuries - Panel 3; Archives of Neurology, 1979; 36; 16, 750

Becker D.P; Miller J.D; Greenberg R; The Outcome in Head Injury in J. Youmans (ed); Neurological Surgery 2nd ed. Philadelphia; W.B. Saunders Co, 1982

Becker D.P; Miller J.D; Ward J.D; Greenberg R.P; Young H.F; and Sakalas R; The Outcome from severe head injury with early diagnosis and intensive management; J. Neurosurgery, 1977; 47; 491 - 502

Beery K.D; Revised administration, scoring and teaching manual for the Developmental Test of Visual-Motor Integration; Chicago; Follett, 1982;

Bender L.A; A Visual motor gestalt test and its clinical use; American Orthopsychiatric Association Research Monographs 1938; No. 3

Benton A.L; Test of three-dimensional block construction; Oxford University Press, 200 Madison Avenue, New York, N.Y. 10016

Benton A.L; Right-left discrimination and finger localization : development and pathology; New York; Hoeber-Harper; 1959

Benton A.L; The Revised Visual Retention Test (4th ed); New York; Psychological Corporation; 1974

Benton A.L; and Fogel M.L; The assumption that a common disability underlies failure in copying drawings and in copying two-and three-dimensional block patterns is not justified; Archives of Neurology, 1962; 7; 347 - 354

Benton A.L; Hamsher K. de S; Varney N.R; and Spreen O; Contributions to neuropsychological assessment; New York; Oxford University Press; 1983

Benton A.L; and van Allen M.W; Impairment in facial recognition in patients with cerebral disease; Cortex, 1968; 4; 344 - 358

Benton A.L; and van Allen M.W; Test of Facial Recognition; New York; Oxford University Press

Benton A.L; Visioperceptive, Visiospatial, and visioconstructive disorders. In K.M. Heilman and E. Valenstein (Eds) Clinical Neuropsychology; New York; Oxford University Press, 1979

Bishop D; Plasticity and Specificity of Language Localization in the Developing Brain; Dev. Med. and Child Neurol, 1981; 23; 251 - 255

Black P; Blumer D; Wellner A; Jeffries J.J; and Walker A.E; An interdisciplinary prospective study of head trauma in children in C.R. Angle and E.A. Bering (eds); Physical Trauma as an Etiological Agent in Mental Retardation : Proceedings of a Conference on the Etiology of Mental Retardation; 13 - 16

Oct. 1968; Omaha, Nebraska; Bethesda Md; Nat. Inst. of Neurological Disease and Stroke, 1970

Black P; Blumer D; Wellner A; Shepard R.H; Walker A.E; Head Trauma in Children; Neurological Behavioural and Intellectual Sequelae in Perry Black (ed); Brain Disfunction in Children; Neurological Behavioural and Intellectual Sequelae, New York; Raven Press, 1981

Black P; Blumer D; Wellner A; Shepard R.H; and Walker A.E; Head Trauma in Children; Neurological behavioural and intellectual sequelae in Perry Black (ed); Brain Disfunction in Children; Etiology, Diagnosis and Management, New York; Raven Press, 1981

Black P; Blumer D; Wellner A.M; and Walker A.E; The head-injured child. Time-course of recovery, with implications for rehabilitation in Head Injuries; Proceedings of an International Symposium held in Edinburgh and Madrid, 1970

Edinburgh; Churchill Livingstone, 1971

Black P; Jeffries J.J; Blumer D; Wellner A.M; and Walker A.E; The post-traumatic syndrome in children; characteristics and incidence in A.E. Walker; W.F. Caveness, and M. Critchley (eds); The late Effects of Head Injury; Springfield IU; Charles C. Thomas, 1969

Bond M.R; Assessment of the psychosocial outcome after severe head injury In Ciba Foundation Symposium No. 34 (New Series); Symposium on the outcome of severe damage to the central nervous system; Amsterdam; Elsevier Excorpta Medica, 1975

Bond M.R; Assessment of psychosocial outcome of severe head injury; Acta Neurochirurgica, 1976; 34; 57 - 70

Bond M.R; Jennett W.B; Brooks D.N; and McKinlay W; The Nature of Physical, Mental and Social Deficits contributing to the categories of good recovery, moderate and severe disability in the Glasgow Outcome Scale; Acta Neurochirurgica, 1979; Suppl. 28; 126 - 127

Borokowski J; Benton A; Spreen O; Word Fluency and Brain Damage; Neuropsychologia, 1967; 5; 135 - 140

Braakman R; Gelpke G; Habbema J; Maas A; and Minderhoud J; Systematic selection of prognostic features in patients with severe head injury; Neurosurgery, 1980; 6; 4; 362 - 370

Bronk J.D; Garrett A.L; Hale W.R; Woo-Sam J; Nickel V.L; Recovery of motor and intellectual function in children sustaining severe head injuries; Develop Med and Child Neurol., 1970; 12, 565 - 571

Brink J.D; Imbus C; and Woo-Sam J; Physical Recovery after severe closed head trauma in children and adolescents; J. Pediatrics, 1980; 97; 5; 721 - 727

Brooks D.N; Memory and Head injury; J. Nervous and Mental Disease, 1972; 155; 5; 350 - 355

Brooks D.N; Recognition memory and head injury; J. Neurol. Neurosurg. and Psych, 1974; 37; 794 - 801

Brooks D.N; Long and short term memory in head injured patients; Cortex, 1975; 11; 329 - 340

Brooks D.N; Wecholer Memory Scale performance and its relationship to brain damage after severe closed head injury; J. Neurol. Neurosurg. and Psych, 1976; 39; 593 - 601

Brooks D.N; Psychological sequelae of head injuries; Scot Med. J., 1978; 23; 104 - 105

Brooks D.N; and Aughton M.E; Cognitive recovery during the first year after severe blunt head injury; Int. Rehab. Med., 1979; 1; 166 - 172

Brooks D.N; and Aughton M.E; Psychological consequences of blunt head injury; Int. Rehab. Med., 1979; 1; 160 - 165

Brooks D.N; Aughton M.E; Bond M.R; Jones P; and Rizvi S: Cognitive sequelae in relationship to early indices of severity of brain damage after severe blunt head injury; J. Neurol. Neurosurg. and Psych., 1980; 43; 529 - 534

Brown G; Chadwick O; Shaffer D; Rutter M; and Traub M: A Prospective study of children with head injuries; III Psychiatric sequelae; Psychological Medicine, 1981; 11; 63 - 78

Bruce D.A; Schut L; Bruno L.A; Woods J.H; and Sutton L.N; Outcome following severe head injury in children; J. Neurosurg., 1978; 48; 679 - 688

Bruce D.A; Special Considerations of the pediatric age group in P.R. Cooper (ed); Head Injury; Baltimore; Williams and Wilkins, 1982

Budzilovich G.N; On Pathogenesis of Primary Lesions in Blunt Head Trauma with special reference to the Brain Stem Injuries in McLaurin R.L. (ed); Head Injuries; 2nd Chicago Symposium on Neural Trauma; New York; Grune and Stratton Inc, 1976

Buschke H; and Fuld P.A; Evaluating storage, retention and retrieval in disordered memory and learning Neurology, 1974; 24; 1019 - 1025

Buschke H; Selective reminding for analysis of memory and learning; J. Verbal Learning and Verbal Behaviour, 1973; 12; 543 - 550

Buschke H; Components of verbal learning in children; analysis by selective reminding; J. Exp. Child Psychol., 1974; 18; 488 - 496

Carlsson C.A; Essen C.V; and Löfgren J; Factors affecting the clinical course of patients with severe head injuries; I Influence of biological factors II Significance of post-traumatic coma; J. Neurosurg, 1968; 29; 242 - 251

Chadwick O; Rutter M; Thompson J; and Shaffer D; Intellectual performance and reading skills after localized head injury in childhood; J. Child Psychol and Psych, 1981a; 22; 117 - 139

Chadwick O; Rutter M; Brown G; Shaffer D; Traub M; A prospective study of children with head injuries II; Cognitive sequelae; Psychological Medicine, 1981b ; 11; 49 - 61

Chadwick O; Rutter M; Shaffer D; Shrout P.E; A prospective study of children with head injuries IV Specific cognitive deficits; J. Clinical Neuropsychology, 1981c ; 3; 2; 101 - 120

Comninos S.T.C; Early prognosis of severe head injuries in children; Acta Neurochirurgica, 1979; Suppl. 28; 144 - 147

Conners C; Rating Scales for use in drug studies in children; In Pharmaco-therapy of Children; 24 - 84; Psychopharmacology Bulletin; Special Suppl to Volume 9

Conners C.K; A teacher's rating scale for use in drug studies with children; American Journal of Psychiatry, 1969; 126; 884 - 888

Costa L.D; Scarola L.M; and Rapin J; Purdue Pegboard scores for normal grammar school children; Perceptual and Motor Skills, 1964; 18; 748

Craft A.W; Head Injury in children in Vinken and Bruyn (eds); Handbook of Clinical Neurology, Vol. 23; New York; Elsevier, 1972

Craft A.W; Shaw D.A: Cartlidge; Head Injuries in children; Brit Med J, 1972; 4; 200 - 203

Cunning J.E; Emotional Aspects of head trauma in children; Rehabilitation Literature, 1976; 37; 11 - 12

Dencker S.J; Closed head injury in twins; Arch Gen. Psychiatry, 1960; 2; 569 - 575
Denckla M; Development of speed in repetitive and successive finger movements in normal children; Devel Med Child Neurol, 1973; 15; 635 - 645

Denckla M; Development of motor coordination in normal children; Devel Med Child Neurol, 1974; 16; 729 - 741

de Villiers J.C; Jacobs M; Parry C.D.H; and Botha J.L; A retrospective study of head injured children admitted to two hospitals in Capetown (In press)

De Vivo D.C; and Dodge P.R; The critically ill child; Diagnosis and management of head injury; Pediatrics, 1971; 48; 129 - 138

DSM-111; Diagnostic and Statistical Manual of Mental Disorders (3rd edition); Washington; American Psychiatric Association Press, 1980

Dikmen S; and Reitan R.M; Emotional sequelae of head injury; Am Neurol, 1977; 2; 492 - 494

Dikmen S; Reitan R.M; and Temkin N.R; Neuropsychological recovery in head injury; Arch Neurol, 1983; 40; 333 - 338

Di Simondi F; Manual for the Token Test for Children; New York; Teaching Resources Corporation, 1978

Dye O.A; Milby J.B; and Saxon S.A; Effects of early neurological problems following head trauma on subsequent neuropsychological performance; Acta Neurologica Scandinavia, 1979; 59; 1; 10 - 14

Dye O.A; Saxon S.A; and Milby J.B; Long-term neuropsychological defects after traumatic head injury with comatosis; J. Clin. Psychology, 1981; 37; 3; 472

Eson M.E; Yen J.K; and Bourke R.S; Assessment of recovery from serious head injury; J. Neurol. Neurosurgery & Psych, 1978; 43; 1036 - 1042

Fabian A.A; Prognosis in head injuries in children; J. Nervous and Mental Disease, 1956; 123; 428 - 431

Fahy T.J; Irving M.H; Millac P; Severe head injuries; Dancet, 1967; 2; 475 - 481

Filskov S.B; and Boll T.J (eds); Handbook of Clinical Neuropsychology; New York; John Wiley and Sons, 1981

Flach J; and Malmros R; A long term follow-up study of children with severe head injury; Scand J Rehabil Med, 1972; 4; 9 - 15

Flowers A; Costello M.R; and Small V; Flowers Costello tests of central auditory abilities; Dearbom, Michigan; Perceptual learning systems, 1970

Fodor I.E; Impairment of memory functions after acute head injury; J Neurol Neurosurg & Psych, 1972; 35; 818 - 824

Frostig M; Maslow P; Le Fever D.W; and Whittlesey J.R.B; Standardization of developmental Test of Visual Perception; Perceptual and Motor Skills, 1964; 19; 463 - 499

Fuld A; Fisher P; Recovery of intellectual ability after closed head injury; Develop Med Child Neurol, 1977; 19; 495 - 502

Gennarelli T.A; Cerebral Concussion and Diffuse Brain Injuries in Cooper, P.R. (ed); Head Injury; Baltimore; Williams and Wilkins, 1982

Gilchrist E; and Wilkinson M; Some factors determining prognosis in young people with severe head injuries; Arch Neurol, 1979; 36; 355

Glanville H.J; Prognosis of severe head injuries; Proc Roy Soc Med, 1972; 65; 613

Gogstad A.C; and Kjellman A.M; Rehabilitation prognosis related to clinical and social factors in brain injured of different etiology; Soc Sci & Med, 1976; 10; 283 - 288

Golden C.J; The Luria-Nebraska Neuropsychological Battery; Theory and Research in P.M. Reynolds (ed); Advances in Psychological Assessment; San Francisco; Jersey-Bass Publishers, 1981

Goldstein G; Shelly C.H; Univariable vs. Multivariable analysis in Neuropsychological Test Assessment of lateralized Brain Damage; Cortex, 1973; 9; 204 - 215

Goodglass H; and Kaplan E; Assessment of cognitive deficit in the brain-injured patient; In M.S. Gazzaniga (ed); Handbook of Behavioural Neurobiology (Vol 2, Neuropsychology); New York; Plenium Press, 1979

Graham F.K; and Kendall B.S; Memory-for-Designs Test; revised general manual; Perceptial and Motor Skills, Monograph Supplement No. 2 - VIII, 1960; 11; 147 - 188

Graham P; and Rutter M; The Reliability and validity of the psychiatric assessment of the child II; Interview with the parent; British Journal of Psychiatry; 114; 581 - 592

Groher M; Language and memory disorders following closed head trauma; J. Speech Hear Research, 1977; 20; 212 - 223

Gronwall D.M.A; Paced Auditory Serial-Addition Task; a measure of recovery from concussion; Perceptual and Motor Skills, 1977; 44; 367 - 373

Gronwall D; and Wrightson P; Delayed recovery of intellectual functioning after mild head injury; Lancet, 1974; 2; 605 - 609

Gronwall D; and Wrightson P; Recovery after minor head injury; Lancet, 1974; 2; 1452

Gronwall D; and Wrightson P; Memory and information processing capacity after closed head injury; J. Neurol Neurosurg Psych, 1981; 44; 889 - 895

Guthkelch A.N; Post-traumatic amnesia, post concussional symptoms and accident neurosis; Eur. Neurol, 1980; 19; 91 - 102

Habbema J.D.F; Braakman R; and Avezaat C.J.J; Prognosis of the individual patients with severe head injury; Acta Neurochirurgica, 1979; Suppl. 28; 158 - 160

Hannay H.J; Levin H.S; and Grossman R.H; Impaired recognition memory after head injury; Cortex, 1979; 15; 269 - 283

Harrington J.A; and Le Temendia F.J.J; Persistent psychiatric disorders after head injuries in children; J Mental Science, 1958; 104; 1205 - 1218

Hawkes C.D; Craniocerebral trauma in infancy and childhood; Clin. Neurosurg, 1964; 11; 66 - 75

Hēcaen H; Acquired aphasia in children and the ontogenesis of hemiophenic functional specialization; Brain Language, 1976; 3; 114 - 134

Heiskanen D; and Kaste M; Late prognosis of severe brain injury in children; Develop Med Child Neurol, 1974; 16; 11 - 14

Hendrick E.B; Harwood-Hash D.C; Hudson A.R; Head injuries in children; a survey of 4465 consecutive cases at the Hospital for Sick Children, Toronto, Canada; Clin Neurosurg, 1964; 11; 40 - 59

Hjern B; and Nylander I; Late prognosis of severe head injuries in childhood; Arch Dis Child, 1962; 37; 113 - 116

Hjern B; and Nylander I; Acute head injuries in children; traumatology therapy and prognosis; Acta Paediatrica Scandinavia, 1964; Suppl 154

Hutt M.L; The Hutt adaption of the Bender-Gestalt test (3rd ed); New York; Grune and Stratton, 1977

Javid M; Current concepts; Head Injuries; New England J Medicine, 1974; 890

Jennett B; Late effects of head injuries in M. Critchley, J.L. O'Leary and B. Jennett (eds); Scientific Foundation of Neurology; Philadelphia; F.A. Davis Co, 1971

Jennett B; Head Injuries in Children; Developmental Medicine and Child Neurology, 1972; 14; 137 - 147

Jennett B; and Bond M; Assessment of outcome after severe brain damage; Lancet, 1975; 1; 480 - 484

Jennett B; Teasdale G; and Knill-Jones R; Prognosis after severe head injury in Ciba Foundation Synposium No. 34, New Series; Outcome of Severe Damage to the Central Nervous System; Amsterdam; Elsevier, Excepta Medica, 1975

Jennett B; Assessment of the severity of head injury; Journal of Neurology, Neurosurgery and Psychiatry, 1976; 39; 647 - 655

Jennett B; Teasdale G; Knill-Jones R; and Braakman R; Predicting outcome in individual patients after severe head injuries; Lancet, 1976; 1; 1031 - 1034

Jennett B; Teasdale G; Galbraith S; Pickard J; Grant H; Braakman R; Avezaat C; Maas A; Minderhout J; Vedit C.J; Heiden J; Small R; Caton W; Kurze T; Severe head injuries in three countries; J. Neurol Neurosurg Psych, 1977; 40; 291 - 298

Jennett B; Teasdale G; Aspects of coma after severe head injury; Lancet, 1977; 1; 878 - 881

Jennett B; Teasdale G; Galbraith; et al; Prognosis in patients with severe head injury; Acta Neurochirurgica, 1979; Suppl 28; 149 - 152

Jennett B; Teasdale G; Braakman R; et al; Prognosis of patients with severe head injury; Neurosurgery, 1979; 4; 4

Jennett B; and Teasdale G; Management of head injuries; Philadelphia; F.A. Davis Co, 1981

Kaufman A.S; Intelligent Testing with the WISC-R; New York; John Wiley & Sons, 1979

Kirk S.A; McCarthy J.J; and Kirk W.D; Illinois Test of Psycholinguistic Ability ; Examiner's Manual (Rev Ed); University of Illinois Press, 1968

Klonoff H; Robinson G.C; and Thompson G; Acute and chronic brain syndromes in children; Developmental Medicine and Child Neurology, 1969; 11; 198 - 213

Klonoff H; and Low M; Disordered brain function in young children and early adolescents; Neuropsychological and electrocencephalographic correlates in Clinical Neuropsychology; Current Status and Applications; R.M. Reitan & L.A. Davison (eds); New York; John Wiley and Sons, 1974

Klonoff H; and Paris R; Immediate short-term and residual effects of acute head injuries in children; neuropsychological and neurological correlates in R.M. Reitan and L.A. Davison (eds); Clinical Neuropsychology Current States and Applications; New York; John Wiley & Sons, 1974

Klonoff H; Low M.D; and Clark C; Head injuries in children; a prospective five-year follow-up; J. Neurology, Neurosurgery and Psychiatry, 1977; 40; 1211 - 1219

Clove H; and Cleeland C.S; Relationship of neuropsychological impairment to other indices of severity of head injury; Scandinavian Journal of Rehabilitation Medicine, 1972; 4; 55 - 60

Knights R.M; and Norwood J.A; A Neuropsychological Test Battery for Children; Ottawa; Psychological Consultants, 1979

Knobel G.J; de Villiers J.C; Parry C.D.H; and Botha J.L; The causes of non-natural death in children under the age of 15 years, over a 15 year period in greater Capetown (In Press)

Kolb B; and Whishaw I.Q; Fundamentals of Human Neuropsychology; San Fransisco; Freeman and Co, 1980

Lacks P; Continued Clinical Popularity of the Bender-Gestalt Test; Response to Bigler and Ehrfurth; Professional Psychology, 1982; 13 (5); 677 - 679

Leary P.M; Report on 3rd International Child Neurology Congress, Copenhagen, Denmark; Unpublished, May 1982

Levin H.S; Hamsher K. de S; and Benton A.L; A Short Form of the Test of facial recognition for Clinical Use; J of Psychology, 1975; 91; 223 - 228

Levin H.S; and Grossman R.G; Effects of closed head injury on storage and retrieval in memory and learning of adolescents; Journal of Pediatric Psychology, 1976; 1; 38 - 42

Levin H.S; Grossman R.G; and Kelly P.J; Short-term recognition memory in relation to severity of head injury; Cortex, 1976; 12; 175 - 182

Levin H.S; Grossman R.G; and Kelly P.J; Aphasic disorder in patients with closed head injury; Journal of Neurology, Neurosurgery and Psychiatry, 1976; 39; 1062 - 1070

Levin H.S; Grossman R.G; and Kelly P.J; Impairment of facial recognition after closed head injuries of varying severity; Cortex, 1977; 13; 119 - 130

Levin H.S; and Grossman R.G; Behavioural sequelae of closed head injury; a quantitive study; Archives of Neurology, 1978; 35; 720 - 727

Levin H.S; Grossman R.G; Rose J.E; and Teasdale G: Long-term neuropsychological outcome of closed head injury; Journal of Neurosurgery, 1979; 50; 412 - 422

Levin H.S; and Eisenberg H.M; Neuropsychological impairment after closed head injury in children and adolescents; Journal of Pediatric Psychology, 1979a; 4; 4, 389 - 402

Levin H.S; and Eisenberg H.M; Neuropsychological outcome of closed head injury in children and adolescents; Child's Brain, 1979b; 5; 281 - 292

Levin H.S; Benton A.C; and Grossman R.G; Neurobehavioural consequences of closed head injury; New York; Oxford University Press, 1982

Levin H.S; Eisenberg H.M; Wigg N.R; and Kobayashi K; Memory and intellectual ability after head injury in children and adolescents; Journal of Neurosurgery, 1982; 11; 5; 668 - 673

Lezak M.D; Recovery of memory and learning functions following traumatic brain injury; Cortex, 1979; 15; 63 - 72

Lezak M.D; Neuropsychological Assessment (2nd ed); New York; Oxford University Press, 1983

Lundholm J; Jepsen B; Thornval G; The late neurological psychological and social aspects of severe traumatic coma; Scandinavian Journal of Rehabilitation Medicine, 1975; 7; 97 - 100

Madge E.M; Senior South African Individual Scale; South African Human Science Research Council, 1964

Madge E.M; Junior South African Individual Scale; M.A.T.L.E.D. S.A. Human Science Research Council, 1981

Mahoney W.J; D'Souza B.J; Haller J.A; Rogers M.C; Epstein M.H; Freeman J.M; Long-term outcome of children with severe head trauma and prolonged coma; Pediatrics, 1983; 71; 5; 756 - 762

Mandleberg I.A; and Brooks D.N; Cognitive recovery after severe head injury 1; Serial Testing on the Wecholer Adult Intelligence Scale; J. Neurol. Neurosurg. Psychiat, 1975; 38; 1121 - 1126

Mandleberg I.A; Cognitive recovery after severe head injury 2; Wecholer Adult Intelligence Scale during post-traumatic amnesia; J. Neurol. Neurosurg. Psychiat, 1975; 38; 1127 - 1132

Mandleberg I.A; Cognitive recovery after severe head injury 3; WAIS verbal and performance IQ's as a function of post-traumatic amnesia duration and time from injury; J. Neurol. Neurosurg. Psychiat, 1976; 39; 1001 - 1007

McCarthy J.J; and Olson J.L; Validity studies on the Illinois Test of Psycholinguistic Abilities; Institute of Research on Exceptional Children; University of Illinois, 1964

McFie J; Assessment of organic intellectual impairment; London; Academic Press, 1975

McFie J; Intellectual impairment in children with localized post-infantile cerebral lesions; Journal of Neurology, Neurosurgery & Psychiatry, 1961; 24; 361 - 365

McKinlay W.W; Brooks D.N; Bond M.R; Martinage D.P; Marshall M.M; The short-term outcome of severe blunt head injury as reported by relatives of the injured persons; Journal of Neurology, Neurosurgery and Psychiatry, 1981; 44; 527 - 533

McLaurin R.L; Head Injuries 2nd Chicago Symposium on Neural Trauma; New York; Grune and Stratton, Inc, 1976

Miller E; The long-term consequences of head injury; a discussion of the evidence with special reference to the preparation of legal reports; British Journal of Social and Clinical Psychology, 1979; 18; 87 - 98

Miller E; Verbal fluency as a function of a measure of verbal intelligence and in relation to different types of cerebral pathology; British Journal of Clinical Psychology, 1984; 23; 53 - 57

Miller J.D; Becker D.P; Ward J.D; Sullivan H.G; Adams W.E; and Rosner M.J; Significance of intracranial hypertension in severe head injury; J. Neurosurg, 1977; 47; 503 - 516

Naughton J.A.L; The effects of severe head injuries in children; Psychological aspects; Proceedings of an International Symposium on Head Injuries; Edinburgh; Churchill Livingstone, 1971; 106 - 110

Neale M.D; Neale Analysis of Reading Ability (Manual); London; MacMillan, 1958

Obrzut J.E; and Hynd G.W: (eds); Neuropsychological Assessment of the school-age child : Consuls & Procedures; New York; Grune & Stratton, 1981

Oddy M; Humphrey M; and Uttley D; Subjective impairment and social recovery after closed head injury; Journal of Neurology, Neurosurgery and Psychiatry, 1978; 41; 611 - 616

Oddy M; Humphrey M; and Uttley D; Stresses upon the relatives of head injured patients; British Journal of Psychiatry, 1978; 133; 507 - 513

Oddy M; and Humphrey M; Social recovery during the year following severe head injury; Journal of Neurology, Neurosurgery and Psychiatry, 1980; 43; 798 - 802

Oldfield R; and Wingfield A; The time it takes to name an object; Nature, 1964; 202 1031 - 1032

Oldfield R; and Wingfield A; Response latencies in naming objects; Quarterly Journal of Experimental Psychology, 1965; 17; 273 - 281

Ommaya A.K; and Gennarelli T.A; Cerebral concussion and traumatic unconsciousness; correlation of experimental and clinical observations on blunt head injuries; Brain, 1974; 97; 633 - 654

Ommaya K.A; Mechanisms of Cerebral Concussion, Contusions and other effects of Head Injury in Youmans, J.R. (ed); Neurological Surgery (2nd edition) Vol 4; Philadelphia; W.B. Saunders Co, 1982

Oppenheimer D.R; Microscopic lesions in the brain following head injury; J. Neurol. Neurosurg. Psychiat, 1968; 31; 299 - 306

Overgaard J; and Christensen S; Prognosis after head injury based on early clinical examinations; Lancet, 1973

Overgaard J; Reflections on prognostic determinants in acute severe head injury in R.L. McLaurin (ed); Head Injuries; 2nd Chicago Symposium on Neural Trauma; New York; Grune and Stratton Inc, 1976

Panting A; and Merry P.H; The long term rehabilitation of severe head injuries with particular reference to the need for social and medical support for the patient's family; Rehabilitation, 1972; 38; 33 - 37

Pendleton M.G; Heaton R.K; Lehman R.A.W; and Hulihan D; Diagnostic utility of the Thurstone Word fluency test in neuropsychological evaluation; Journal of Clinical Neuropsychology, 1982; 4; 307 - 317

Plum F; and Posener B; Pathological physiology of signs and symptoms of coma in F. Plum and B. Posener (eds); Diagnosis of Stupor and Coma (2nd ed); Philadelphia; F.A. Davis Co, 1973

Purdue Research Foundation; Examiners Manual for the Purdue Pegboard; Chicago; Science Research Associates, 1948

Reed H.B.C; Reitan R.M; and Klove H; Influence of Cerebral Lesions on psychological test performances of older children; J. Consulting Psychology, 1965; 29; 247 - 251

Reed H; and Fitzhugh K; Patterns of defects in relation to severity of cerebral dysfunction in children and adults; Journal of Consulting Psychology, 1966; 30; 98 - 102

Reitan R.M; and Davison L.A; Clinical Neuropsychology current status and applications; New York; Hemisphere, 1974

Renfrew C; Word-Finding Vocabulary Scale; Oxford, 1968

Richardson F; Some effects of severe head injury; Developmental Medicine and Child Neurology, 1963; 5; 471 - 482

Robinson R; Equal recovery in child and adult brain?; Developmental Medicine and Child Neurology, 1981; 23; 379 - 383

Rodin E.A; Contribution of the EEG to prognosis after head injury; Journal of Clinical Psychiatry, 1967; 28; 595 - 600

Romano M.D; Family response to traumatic head injury; Scandinavia Journal of Rehabilitation Medicine, 1974; 6; 1 - 4

Rosvold H.E; Mirsky A.F; Sarson I; Bransome E.D; and Lloyd H.B; A continuous Performance Test of Brain Damage; Journal of Consulting Psychology, 1956; 20; 343 - 350

Rune V; Acute head injuries in children. A retrospective epidemnologic and electroencephalographic study on primary school children in Umea; Acta Paediatr. Scand, 1970; 209; 3 - 12

Russell W.R; and Smith A; Post-traumatic amnesia in head injury; Archives of Neurology, 1961; 5; 16 - 29

Rutter M; A children's behaviour questionnaire for completion by teachers; Preliminary Findings Journal; Child Psychology and Psychiatry, 1967; 8; 1 - 11

Rutter M; Graham P; and Yule W; A Neuropsychiatric study in Childhood; London; Spastics International Medical Publications, 1970

Rutter M; Chadwick O; Shaffer D; and Brown G; A prospective study of children with head injuries; I Design and methods; Psychological Medicine, 1980; 10; 633 - 645

Rutter M; Psychological sequelae of brain damage in children; American Journal of Psychiatry, 1981; 138

Sarno M.T; The nature of verbal impairment after closed head injury; Journal of Nervous and Mental Disease, 1980; 168; 685 - 692

Schacter D.L; and Crovitz H.F; Memory function after closed head injury; a review of the quantitive research; Cortex, 1977; 13; 130 - 176

Selz M; and Reitan R.M; Neuropsychological test performance of normal learning-disabled and brain-damaged older children; Journal of Nervous and Mental Disease, 1979a; 167; 298 - 302

Selz M; and Reitan R.M; Rules for neuropsychological diagnosis; classification of brain function in older children; Journal of Consulting and Clinical Psychology, 1979b; 47; 258 - 264

Shaffer D; Chadwick O; and Rutter M; Psychiatric Outcome of localized head injury in children in Ciba Foundation Symposium 34 New Series; Outcome of Severe Damage to the Central Nervous System; Amsterdam; Elsevier, 1975; 191 - 213

Shaw J.F; Head injuries in children and their sequelae in Head Injuries; Proceedings of an International Symposium held in Edinburgh and Madrid, 1970; Edinburgh; Churchill Livingstone, 1971

Siegel S; Nonparametric Statistics for the Behavioural Sciences; New York; McGraw-Hill Book Co, Inc, 1956

Sisler G; and Penner H; Amnesia following severe head injury; Canadian Journal of Psychiatry, 1975; 20; 5; 333 - 336

Smith A; Symbol Digit Modalities Test Manual; Los Angeles; Western Psychological Services, 1973

Smith A; Neuropsychological Testing in Neurological Disorders In W.J. Friedlander (ed); Advances in Neurology (Vol 7); New York; Raven Press, 1975

Smith E; Influence of site of impact on cognitive impairment persisting long after severe closed head injury; Journal of Neurology, Neurosurgery and Psychiatry, 1974; 37; 719 - 726

Spreen O; and Benton A.L; Comparative Studies of some psychological tests for cerebral damage; J. Nervous and Mental Disease, 1965; 140; 323 - 333

Spreen O; and Benton A.L; Sentence Repitition Test, administration, scoring and preliminary norms; Iowa City, Iowa; Murieo, 1963

Spreen O; and Benton A.L; Neurosensory Centre Comprehensive Examination for Aphasia; Victoria, B.C; Neuropsychological Laboratory Dept. of Psychology, University of Victoria, 1969

Spreen O; and Gaddes W.H; Developmental Norms for 15 Neuropsychological Tests age 6 to 15; Cortex, 1969; 5; 170 - 191

St James-Roberts I; Neurological plasticity, recovery from brain insult and child development; Advances in Child Development and Behaviour, 1979 14; 253 - 319

Stover S.L; and Zeiger H.E; Head injury in children and teenagers; Functional recovery correlated with duration of coma; Arch. Phys Med. Rehabil, 1976; 57; 201 - 205

Strich S.J; Diffuse Degeneration of the Cerebral White Matter in severe dementia following head injury; J. Neurol. Neurosurg. Psychiat, 1956; 19; 163 - 185

Strich S.J; Shearing of nerve fibres as a cause of brain damage due to head injury; Lancet, 1961; 11; 443

Strich S.J; The Pathology of brain damage due to blunt head injuries, in The Late Effects of Head Injury; A.E. Walker; W.F. Careness and M. Critchley (ed); Springfield; Charles C. Thomas, 1969; 501 - 526

Strich S.J; Lesions in the Cerebral Hemispheres after blunt head injury, in The Pathology of Trauma; S. Sevitt and H.B. Stoner (eds); London; BMA House, 1970; 166 - 171

Symonds C.P; Concussion and its sequelae; Lancet; 1962; 1; 1

Tabaddor K; Emergency Care; Initial Evaluation in Cooper, P.R (ed) Head Injury; Baltimore; Williams and Wilkins, 1982

Taylor E.M; The Appraisal of Children with Cerebral Deficits; Cambridge; Mass; Harvard University Press, 1959

Teasdale G; and Jennett B; Assessment of coma and impaired consciousness; A Practical Scale; Lancet, 1974; 2; 81 - 84

Teasdale G; Assessment of head injuries; British Journal of Anaesthetics, 1976; 48

Terman L.M; and Merrill M.A; Stanford-Built Intelligence Scale; Manual for the Third Revision; Form L - M; Boston; Houghton Mifflin, 1973

Thomsen I.V; Evaluation and outcome of aphasia in patients with cerebral trauma; Journal of Neurology, Neurosurgery and Psychiatry, 1975; 38; 713 - 718

Thomsen I.V; The patient with severe head injuries and his family; Scandanavian Journal of Rehabilitative Medicine, 1976; 48

Thomsen I.V; and Skinhoj E; Progressive language in severe head injury; Acta Neurologica Scandinavica; 1976; 54; 219 - 226

Todorow S; Recovery of children after severe head injury; Scandinavian Journal of Rehabilitative Medicine, 1975; 7; 93 - 96

Van Wowern F; Post-traumatic amnesia and confusion as an index of severity in head injury, 1966; 42; 373 - 378

Vogel F.S; The Anatomy of head trauma; Pathology Annuals, 1971

Walker A.E; Mechanisms of cerebral trauma and impairment of consciousness in J.R. Youmans (ed); Neurological Surgery, (Vol 2); Philadelphia; Saunders, 1973

Walsh K.W; Neuropsychology; A Clinical Approach; New York; Churchill Livingstone, 1978

Wechsler D; Wechsler Preschool and Primary Scale of Intelligence; New York; Psychological Corporation, 1967

Wechsler D; WISC-R Manual; WechslerIntelligence Scale for Children - Revised; New York; Psychological Corporation, 1974

Wedell R; Oddy M; and Jenkins D; Social adjustment after rehabilitation; a two year follow-up of patients with severe head injury; Journal Neurology, Neurosurgery and Psychiatry, 1980; 43; 257 - 263

Wepman J.M; Auditory Discrimination Test; Form I and II; Chicago; Illinois Language Research Associates, 1958

Wepman J.M; and Jones L.V; Language Modalities Test for Aphasia, 1961

Wilkinson M.I.P; Prognosis of severe head injuries in young adults; Proc. Roy. Soc. Med, 1969; 62; 541

Youmans J.R (ed); Philadelphia; W.B. Saunders Co, 1982

Neurological Surgery (2nd ed); Vol 4; Trauma

Zagar R; Arbit J; and Friedland J; Structure of a Psychodiagnostic Test Battery for Children; J of Clinical Psychology, 1980; 36 (i); 313 - 318

APPENDIX A

PSYCHOSOCIAL ASSESSMENT
INTERVIEW FORMAT

RETROSPECTIVE SURVEY OF HEAD INJURY IN CHILDHOOD

PSYCHO-SOCIAL ASSESSMENT

NOTE: "Before" refers to details relevant prior to the occurrence of the head injury in question.

"Since" refers to details relevant following the occurrence of the head injury in question.

1. PSYCHO-SOCIAL ASSESSMENT

A. PATIENT

(a) Identifying Details

1. Folder Number
2. Ward to which admitted after injury
3. Surname
4. First Name
5. Address
6. Telephone number
7. Additional details (contact numbers)
8. Litigation:

    Successful
    Unsuccessful
    In progress
    Time taken

Details

9. Date of birth
10. Race
11. Sex
12. Home language
13. Family religion

(b) History

(b-1) Developmental

14. Pregnancy:

    Full term
    Premature
    Unknown

15. Labour:

Normal/average
Very short (precipitous)
Very long (12 - 18 hours)
Unknown

16. Delivery:

Normal (no problems)
Forceps
Suction
Caesarian
Unknown

17. Post Natal: (no, yes, unknown)

Jaundice
Breathing difficulties
Failure to thrive

Details: (e.g. unsupervised delivery, induced labour, incubator)

18. Milestones: (Age in months)

Normal
Advanced
Slow
Retarded
Unknown

18.1 Motor development:

(i) Sitting unsupported ..... months

(ii) Crawling ..... months

(iii) Walking alone ..... months

18.2 Language development:

(i) Words ..... months

(ii) Sentences ..... months

18.3 Other - Toilet Training:

(i) Out of nappies by day ..... months

(ii) Out of nappies by night ..... months

(iii) Accidental wetting ..... months

(iv) Bedwetting ..... months

(v) Still in nappies ..... months

Details

(b-2) Health

19. As baby under 2 years:

Normal
Very quiet
Crying/irritable
Unknown

20. Serious illnesses under 14 years:

BEFORE	No Yes Unknown
SINCE	No Yes Unknown

Details

21. Serious Accidents (excluding head injury):

BEFORE	No Yes Unknown
SINCE	No Yes Unknown

Details

22. Head Injury:

BEFORE DOCUMENTED H.I.	No Yes Unknown
SINCE DOCUMENTED H.I.	No Yes Unknown

Details

23. Problems with Reception:

BEFORE/ SINCE	Eyesight Hearing Balance/Coordination

Details

24. Convulsions: (No; yes; unknown)

BEFORE/ SINCE	Febrile convulsions Epileptic convulsions

Details

25. Other Chronic Illnesses:

BEFORE No
Yes
Unknown

SINCE No
Yes
Unknown

Details

26. Operations (excluding those specific to the H.I.)

BEFORE No
Yes
Unknown

SINCE No
Yes
Unknown

Details

27. Physical Symptoms: (BEFORE/SINCE)

Headache
Nausea
Dizziness
Sensitivity to noise
Fatigues easily
Blackouts
Speech disturbances
Sensory problems
Motor weakness
Incoordination

Eating problems
Sleeping problems
Bladder/bowel control
Bedwetting

28. Medication:

BEFORE No
Yes
Unknown

SINCE No
Yes
Unknown

Details

29. Mental Symptoms: (BEFORE/SINCE)

Impaired attention/concentration
Memory: forgetfulness
learning difficulties

(b-3) Behaviour

Do you think that he/she has any behaviour/emotional difficulties? Any difficulties with his/her nerves? Do you think that the difficulties are more than most boys/girls of his/her age have?

BEFORE
No
Yes
Unsure

SINCE
No
Yes
Unsure

30. Problems (BEFORE/SINCE) related to:

Activity:
Very active
Hyperactive
Underactive

Control:
Impulsive (acts without thinking)
Talkative
Asks embarrassing questions - personal remarks
Careless (dress, hygiene)
Attention seeking
Irritable/impatient
Aggressive
Low tolerance for stress, frustration
Fussy, overparticular (obsessional)
Anxiety: specific fears
worried, fearful

Moods:
Tearful/depressed
Apathetic, lacks volition
Withdrawn
Too cheerful/pathological laughs
Changes easily

Conduct disorder:
Discipline problem
Stealing
Lying
Truanting
Other

Additional comments

(b-4) Education

DETAILS BEFORE ACCIDENT

31. Pre-school training:

    No
    Yes

Details

32. School standard reached

33. School details:
    (a) Name of school ....
    (b) Headmaster/mistress ....
    (c) Class teacher ....

34. Details on changes: (Time, number, reasons)

35. School attendance:

    Not applicable
    Regular
    Irregular

DETAILS AFTER ACCIDENT

36. Any change of school:

    Standard
    Class
    Teacher
    Principal

37. Any change in school attendance

    Not applicable
    Regular
    Irregular

38. How long after injury did patient go back to school? (state in weeks)

    Not applicable
    1 week
    2 weeks
    3 weeks
    4 weeks
    5 weeks
    6 weeks and over

39. School progress: (BEFORE/SINCE)

Not applicable
Above average
Average
Struggling
Failing (number of times ....)
Special class
Left school - repeated failure

Details

40. Best subject: (BEFORE/SINCE)

Not applicable
Maths/Science
Language
Content subjects
Practical
Other (specify)

41. Poorest subject: (BEFORE/SINCE)

Not applicable
Maths/Science
Language
Content subjects
Practical
Other (specify)

Details (e.g. struggles with all subjects)

42. Details on Extra lesson/Remedial teaching

BEFORE No
Yes

SINCE No
Yes

43. Study Habits: (BEFORE/SINCE)

Not applicable
Disciplined
Exceptionally hardworking
Irregular

44. Relationship with teachers: (BEFORE/SINCE)

Not applicable
Good
Fair
Bad

45. Right/Left Domination: (BEFORE/SINCE)

Unknown
Right
Left
Ambidextrous

46. Extra-Mural activities/Leisure activities: (BEFORE/SINCE)

No
Yes

Details: i.e. Art/Music
Hobbies/Interests
Organizations
Sport

47. Friends: (BEFORE/SINCE)

Not applicable (i.e. babies)
Many friends - all ages. No problems
A few friends (if most younger, score 3)
Most younger
Solitary

48. Nutrition:

Details: Breakfast

Lunch

Supper

Unknown
Adequate
Unbalanced (e.g. insufficient protein)
Inadequate

B. FAMILY COMPOSITION AND DETAILS

AT PRESENT:

(a) Father (-figure)

49. Relationship to patient:

No father figure
Biological
Adopted
Step
Foster
Other (specify - e.g. Grandfather, Uncle, M's boyfriend etc)

50. If father-figure is not biological father, details on biological father:

No details, whereabouts unknown
Deceased
Separated from child; occasional contact
Separated from child; no contact

Details

51. Identifying details (father figure):

Name: ....

Age : ....

52. State of marriage:

Unmarried - no mother figure
Married
Widowed
Divorced
Separated
Cohabiting
Indefinite relationship (e.g. father has a girlfriend)

53. Education:

Unknown
Degree
Diploma
Standard 10
Standard 8
Standard 6
Standard 3
None
Other (specify)

54. Occupation:

....

Unknown
Professionals, business managers, executives directors
Employees, administrative-, clerical- and technical workers
Skilled manual and semi-skilled
Unskilled/labourer
Pensioner
Unemployed - no income

55. Job Stability:

Not applicable
Stable (few years, works every day)
Settling (few months, works every day)
Unstable (changes frequently, does not work every day)

56. Income Source:

Not applicable
Salary
Wage
Pension/grant
Works on commission
Other (specify)

(b) Mother (-figure)

Repeat above sections 57 to 64.

65. Total Family Income (per month):

Father	....	pw	....	pm
Mother	....	pw	....	pm
Other	....	pw	....	pm

66. Total Net Income per month (R.c.)

67. Number dependent on above income

(c) Children: (State birth rank and whether still living with parents)

Name	Age	School/ Occupation	Std/ Std Achieved	Number of times Failed

68. Total number of children living with parents.

69. Birth Rank of patient

70. Birth control

(d) Other Occupants:

Name	Relationship	Age	Other details

71. Total number of other occupants

(e) Changes in family composition

72. Any previous members of the family who have now left the home.

Details: (if parent figure, include details as given under B (a) and (b))

73. Number of children who have left the family

74. Changes in number of other occupants

75. Changes in occupation of father, mother or other

Details

76. Changes in income

Details

C. SOCIAL CIRCUMSTANCES

(a) Details on family relations: (at the time of the accident
(State quality of marital and other interpersonal relations)

77. Stress in any interpersonal relations at time of accident

No
Yes

78. Family Cohesion since accident:

No change in relationships
Improved relationships
Deteriorated relationships

Details

(b) Housing

AT PRESENT:

79. Type of Housing:

House
Flat
Squatting
No house; sleeps in bush, parks, etc
Other (specify)

Details on housing:

(a) Number of rooms ....
(b) Facilities ....
(c) Rent ....
(d) How is neighbourhood described ....

80. Number of persons sharing room with patient

81. Number of persons sharing bed with patient (thus excluding patient)

82. Quality of housing:

Good (no overcrowding, no lack of facilities)
Fair/adequate (either crowded or lack of facilities)
Poor/inadequate (both overcrowded with lack of facilities)

(Overcrowded - patient: room ratio of 3:1;
bed ratio of 2:1)

83. Changes in housing and crowding over years (i.e. any significant changes)

(c) Child Care (re patient)

AT PRESENT:

84. Day Care (Pre-school:

Not applicable
Father/mother
Other adult (specify)
Care centre
Other child (specify age)
None (i.e. child cares for him/herself)

85. After School Care:

Not applicable
Father/mother
Other adult (specify)
Care centre
Other child (specify age)
None (i.e. child cares for him/herself)

86. Care during school holidays:

Not applicable
Father/mother
Other adult (specify)
Care centre
Other child (specify age)
None (i.e. child cares for him/herself)

87. Any change in child care over years (no; yes)

Details: (e.g. mother unemployed because of care for the child, trained/untrained attendant, transport, institutionalization)

(d) Health

88. Member of family with physical illness (no; yes)

Details

89. Member of family with psychiatric problem (no; yes)

Details

(e) Socio-cultural activities and use of leisure time

Details

90. Constructive use of leisure in family

91. Change in use of leisure over the years

Details

(f) Social Problems (no; query; yes) (BEFORE/SINCE)

92. Alcoholism/alcohol abuse

Details

93. Drug abuse

Details

94. Crime

Details

95. Anti-social behaviour

Details

96. Child abuse/neglect

Details

97. Financial

Details:

Adequate, no problems
Struggling, but manages to cope
Inadequate

98. Welfare Organization involved (no; yes)

Details